SHIPBUILDING DESIGN/PRODUCTION INTEGRATION WORKSHOP

VOLUME I

U.S. DEPARTMENT OF COMMERCE

MARITIME ADMINISTRATION

IN COOPERATION WITH

NEWPORT NEWS SHIPBUILDING

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Proceedings of the Shipbuilding Design/Production
Integration Workshop

Atlanta, Georgia

January 18 - 21, 1981

Under the auspices of the

Ship Production Committee

of the Society of Naval Architects and Marine Engineers

Volume I

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Volume I

Newport News Shipbuilding
4101 Washington Avenue
Newport News, Virginia 23607
804 380 2000

February 25, 1981

Mr. Ellsworth L. Peterson
Chairman
SNAME/Ship Production Committee
Peterson Builders, Inc.
101 Pennsylvania Street
Sturgeon Bay, Wisconsin 54235

Dear Ellsworth:

The need for U. S. shipbuilders *to* develop an integrated design and production system resulting in lower costs and reduced time between contract award and delivery has been generally recognized. The communication of data on foreign shipbuilding practices through the efforts of the SNAME Ship Production Committee and the Maritime Administration's National Shipbuilding Research Program brought this need into sharp focus. Improvement of the interfaces and communication between design and production is only a partial solution. The need is for full integration of the two functions with design being considered as the first step in the production sequence.

Newport News Shipbuilding (NNS) perceived the need for this important conceptual change in the basic approach to shipbuilding. Research and discussion with our counterparts in all aspects of the U. S. shipbuilding industry confirmed the commonality of the need for design/production integration.

NNS presented a brief paper to the executive committee of the SPC at their meeting in Philadelphia October 13 - 17, 1980 to determine if that body considered the subject worthy of a follow-on effort. Consensus approval was given for a conference/workshop to assess the shipbuilding industry's demand for a SPC panel on this subject and to develop a task outline should the demand exist.

The SNAME/SPC conference and workshops were held in Atlanta from January 18 through 21, 1981. Attendance included participants representing 10 shipyards, two universities, MarAd, ABS, National Academy of Science, IIT Research Institute, design agent and consulting firms. The extent of the recognition of the problem and the demand for an industry-wide approach *to* the solution exceeded our expectations, as did the professionalism and dedication of the participants. Consensus approval of the participants for the necessary industry-wide approach to the subject of design/production integration was certainly provided. The tasks for the proposed panel were outlined and the scope of work considerably broadened. The meeting was a gratifying and learning experience for all who participated. The conference participants, and others who could not attend, want to undertake this work.

Should the SNAME/Ship Production Committee approve the creation of a panel to address the industry-wide need for Design/Production Integration, Newport News Shipbuilding would be pleased to enter into an agreement with MarAd to lead this effort.

Sincerely yours,

T. J. O'Donohue
Director, Manufacturing Engineering

emb
Attachment
Copies to:
Ship Production Committee
Participants in the Shipbuilding
  Design/Production Integration Workshop

PREFACE

The title of the proposed panel has evolved along with the original concept and scope of work.

The initial nomenclatures of "Organization for Production" and "Production/Engineering Integration" are no longer viable.

The word "organization" has become synonymous with personnel charts to many in the shipbuilding industry. The inordinate preoccupation of the industry with organization structure, rather than integrated functions, is perhaps inevitable considering the frequent reorganizations at the shipyards. The tasks to be undertaken by the panel are functional needs and are independent of shipyard organization. The term "organization" has been discarded.

"Production/Engineering Integration" has been replaced by "Design/Production Integration." Design comes first as the initial step in the production sequence. The "engineering" has been omitted in recognition that engineers are also in production.

Planning for Design/Production Integration would adequately stress the importance of the planning function. Because the need for planning and action is implicit, and again for the sake of brevity, the title has become

Design/Production Integration

Paraphrasing Mr. Wiedenhaefer of Grumman Aerospace during his presentation on CAD/CAM at the Atlanta meeting, the objective is to remove the bar between design and production. Hence, our logo

Design/Production
Integration

Design/Production Integration

OVERVIEW

Introduction
John Cartner and Michael Gaffney

The success of the National Shipbuilding Research Program is attributable in no small measure to the unique process of industry-government involvement in the planning and implementation of projects. As part of that process, a conference and workshop took place in Atlanta, Georgia, January 18-21, 1981, to explore industry and MarAd cooperation in a program area new to U. S. shipbuilding engineering/production integration.

The goal of the conference was to facilitate industry thinking in the formulation of engineering/production integration research projects under the auspices of the Ship Production Committee of SNAME (with the sponsorship of MarAd's National Shipbuilding Research Program). A second goal was to establish an industry advisory panel (under the Ship Production Committee) to provide continuous guidance on the topic. Newport News Shipbuilding, acting as lead yard, was asked to organize the conference.

The purposes of the conference were twofold:

(1) to inform the U. S. shipbuilding industry of engineering/production integration methods and techniques as applied in foreign yards and in other U. S. industries, and

(2) to provide a forum for a discussion of the applicability of such innovations to U. S. shipbuilding.

The first goal was achieved by means of four technical presentations made by experts in fields related to engineering and production coordination. They were:

Sigurdur Ingvason
Sivert Jorud
Ralf Ohlin
Intershipping Consultants Ltd.

Roger Vaughan
A&P Appledore Ltd.

Paul Wiedenhaefer
Grumman Aerospace, Inc.

Yoshinobu Ichinose
Yukinori Mikami
IHI Marine Technology, Inc.

These formal presentations were followed by workshops organized to achieve the "feedback" function of the conference. Because the topic was the integration of engineering and production functions, workshop panel composition was purposely not made on the basis of shipyard specialization or professional discipline. Therefore, conference participants from engineering, production, planning and agencies external to shipyards, were mixed in three similarly chartered groups (in the sense that no topics were assigned to the panels). Each group addressed any subject pertaining to the conference theme. This lack of specific direction was intended as a method of gauging the relative strengths of industry’s various interests related to engineering/production integration. This mixture no doubt contributed to the similarity of the recommendations reported by each of the three workshop panels.

OVERVIEW

“One View”

The following section is reproduced through the kind permission of Leon F. McGinnis.

Mr. McGinnis provides an “outsider’s” view that is provocative, as well as objective. Please provide reactions to Leon as requested.

GEORGIA INSTITUTE OF TECHNOLOGY

SCHOOL OF INDUSTRIAL AND SYSTEMS ENGINEERING

Atlanta, Georgia 30332 (404) 894-2300

February 10, 1981

T. J. O'Donohue
Newport News Shipbuilding
4101 Washington Avenue
Newport News, Virginia 23607

Dear Tom:

I appreciated the opportunity to participate in the Engineering/Production Integration Workshop and feel like I learned quite a lot. At the risk of appearing presumptuous, I've tried to write down my reflections on what transpired. I fully realize that I'm pretty uneducated when it comes to shipbuilding, but I do have an avid interest in the industry, particularly the opportunities for industrial engineers. With that in mind, I would value your reaction to the enclosed discussion paper.

I think the goals you've set for yourself in this area are admirable. You're addressing the management group that's critical in terms of solving some of the fundamental productivity problems.

Sincerely,

Leon F. McGinnis

Leon F. McGinnis, Ph.D., P.E.
Associate Professor

LFM:vld

enclosure

Engineering/Production Integration Workshop: One View

The following is intended only as a discussion piece. The author is by no means an expert in shipbuilding, and fully recognizes this.

On January 19, 20, and 21, a workshop sponsored by Newport News and MarAd was held in Atlanta and attended by designers, engineers and planners from U.S. yards, by consultants in shipbuilding management and by" several academicians. While the theme of this workshop was nominally the integration of ship design and engineering functions with ship production functions, a substantial amount of discussion was directed toward the broader problem of productivity in U.S. shipbuilding and, in particular, the large differences in productivity between most domestic and the best foreign shipbuilders.

WHAT THE SHIPBUILDERS SAID

In the early stages of the workshop, a number of circumstances and situations were put forth to explain why U.S. yards do not or cannot realize the same levels of productivity as, say, IHI. Among themwere the following, considered in no particular order. (I will attempt to give a brief summary of each "opinion.")

Vendors. Our vendors don't see us as a significant market. They are not cooperative in providing the design information which we need for early material definition and quite often they saddle us with substantial material delivery delays. These (unplanned) material delays prevent us from fully exploiting preoutfitttig opportunities and both directly and indirectly lead to longer build cycles and higher construction costs.

Labor. *We* have very strong unions with strict, inflexible work practice rules, which prevent us from getting good labor utilization (welders can't fit and fitters can't weld, etc.). We have high absenteeism which disrupts the flow of production. Our turnover rates are very high, so we don't have a large pool of experienced shipbuilding labor. The average level of training/experience/capability of our labor force is low. All these factors naturally lead to low productivity.

Facilities. Our facilities are not up to date. We are limited in crane capacity/shop areas/NC equipment, etc. It's difficult for us to justify the expenditures necessary to modernize.

Procurement. Within our own organization, we don't get the cooperation we need from the procurement function. They don't communicate with us and they don't transmit all our requirements to the vendors.

ECN. We get so many design changes and ECN'S that it's nearly impossible to plan everything in advance. All these changes lead to additional design and engineering, they disrupt the flow of production, and can involve material, design, and rework delays.

Design. The designs that we get to build are not developed with an appreciation of their difficulty or expense in construction. Often the pieces are needlessly complex to fabricate, the structures cannot be broken conveniently into blocks that are sized appropriately for our yard, and the outfitting, equipment, and machinery are specialty items rather than standard. (This seemed to be especially true for designs developedby external design agents.)

Regulatory Bodies. It takes too long to get approvals from the various regulatory bodies. The resulting delays increase the build time and the cost.

There seemed to be general agreement among the majority of the workshop participants that these factors constitute the "reality" of shipbuilding in the U.S. Moreover, the participants seemed to feel that, by and large, these factors are unique to domestic shipyards, and represent a substantial portion of any observed productivity differences between domestic and foreign yards. There is no question that U.S. shipbuilders recognize the problems they face.

As the workshop progressed, however, at least some practices were recognize as being both a hindrance to productivity improvement and, at least conceptually, possible to change. More on that later.

WHAT THE CONSULTANTS SAID

The common themes in all the consultant presentations (though not stated quite this way) were:

(1) make it easy for individuals to take the right (i.e., most productive) action, whether they are designers, planners, workers, etc., and

(2) plan for and maintain close (not the same as rigid) control of all phases from design to delivery.

Each of the consultants described both general approaches and specific techniques for attaining these ends. A summary of some of their main points follows.

Standardize. Both in Europe and Japan, there are industry standards for much of the purchased machinery and equipment. Thus, the designers and engineers have immediate access to the specifications of many purchased components, including the footprint and envelope. Not only does this facilitate early material definition (hence design, production engineering and planning) but it also simplifies the procurement process.

Standardization goes-beyond this, however. It also applies to design and engineering practice. For example, the A&P Appledore presentation described standardized "egg crate" units which could be combined in various ways to yield units of several different sizes. The recent publication, Outfit Planning (December, 1979, Todd Pacific Shipyards Corporation), destribes IHI practices such as standard heights for pipe centerlines, modular support blocks, etc.

Vendor Relations. Both Intershipping and IHI emphasized the importance of good relationships between shipbuilders and vendors. Rather than discussing means for coercing vendors to service shipbuilders needs, both talks focused on cooperation, willingness of the shipbuilder to work with vendors in engineering, when required, and perhaps most importantly, a willingness to take calculated risks in some cases by placing an order for long lead time items in advance of actual contract award. It is quite likely that standardization simplifies relationships with vendors, since many items require no significant negotiation.

Transition. IHI especially emphasized the need for a well-defined transition between the system orientation of design and a product orientation for production engineering and planning. This was seen as a key aspect of engineering/production integration.

Requirements Definition. All three shipbuilding consultants emphasized the importance of early definition of the design to allow early material definition. A corresponding point was also emphasized, namely, that design changes were intensely discouraged once the contract is awarded. In order to make this possible, the shipbuilder will typically have to "invest" a significant design effort prior to contract award to ensure that the design specification is virtually complete at contract award.

Design. All three shipbuilding consultants mentioned the importance of designing for production. Since the design (e.g., the location of bulkheads) controls the subsequent definition of assemblies and hull blocks, it should incorporate considerations of yard capabilities, such as lifting capacities. Also, each piece should be examined to discover if its function can be served by an alternative design which is easier and cheaper to produce.

The Grumman presentation described a computer aided system for drafting and design. In particular applications, this system yielded estimated savings of 50% in engineering, 50% in drafting and 30% in manufacturing (through increased/improved use of N/C equipment). While this type of system has significant promise in shipbuilding, it does not appear to address any of the fundamental underlying productivity problems. Instead it appears to offer a means of vastly improving the productivity of designers and engineers, rather than, necessarily, leading to better designs per se.

Accuracy Control. All the consultants emphasized the need for accuracy, both in production and design. The computer aided design system described by Grumman incorporated some automatic dimensioning evaluations and was claimed to have vastly improved fit-up productivity. In a similar vein, the need for accurate, easy-to-follow production drawings and isometrics was emphasized by the Appledore Intershipping and IHI speakers. All seemed to be arguing, either directly or indirectly, for a central control point for design and engineering data, and for production drawings and instruction.

Scheduling. While all three shipbuilding consultants mentioned the importance of production scheduling, the IHI speaker especially emphasized it. The gist of his statement was that in IHI, they planned the production schedule to guarantee that as soon as a worker finishes one task, his next task is ready for him to begin working. Mr. Ochinore observed that many times, U.S. workers are idle because there is no work planned for them.

Four basic guidelines for scheduling were given during the presentations:

(1) plan the schedule to prevent delays caused by material or unit delays

(2) plan the schedule to have a smooth flow in production

(3) pay attention to detail at the planning stage

(4) maintain constant, convenient, flexible feedback from production to scheduling, engineering and design.

In reviewing the consultant presentations, it seems that a number of techniques have been described which could be directly applied.in U.S. yards, e.g., drawing control techniques or computer aided design. More importantly, the presentations have revealed some more basic problems which will require more effort to solve.

SOME OBSERVATIONS

In discussing U.S. shipbuilding productivity, and especially in attempting to make comparisons to foreign yards, there are real difficulties stemming from a lack of clearly defined, commonly accepted terminology. For example, -what, exactly, is a “delay”? This simple term can have so many interpretations that to use it without qualification leads almost inevitably to misunderstanding. As another example, how do you measure the productivity of labor? Unless we have a common understanding of the accounting for “delays” and other idle time, we have no common basis for discussion or for comparison between different shipbuilding methods.

Likewise, in comparing U.S. shipyards to foreign yards, it is essential to have a firm grasp of the sociological and economic differences between them. At present, it-seems that the only widely known difference is that IHI has build times and costs that are less than half the U.S. figures. Not so well understood is the extent to which labor practices at IHI contribute to this difference. For example, the flexibility to cross trades (fitters can weld and welders can fit) could result in significant productivity improvements. Mr. Ochinose of IHI indicated that if the yard didn't have enough construction work to operate at capacity, then everyone worked shorter hours (i.e., less than 40 hours per week). In most U.S. yards, however, either the existing work simply takes longer, or, in the extreme, there are lay-offs.

Without recognizing and understanding the differences, it is very difficult to make meaningful. comparisons between IHI and U.S. yards. Furthermore, if we don't understand these differences, we can expect to be less than completely successful in adapting the IHI technology for use in U.S. yards.

A SYNTHESIS

In an attempt to synthesize the various viewpoints that were expressed, perhaps it will be helpful to first attempt to enumerate the various symptoms. that were identified and then try to formnulate some programs for solving the underlying problems.

As a first cut, there seem to be three broad categories of symptoms, described briefly below:

Delays. A delay is defined here as an event which is caused by some entity outside the yard and results in less than full (or planned) utilization of one or more yard resources (e.g., labor or crane capacity). Delays can be further categorized as:

(1) material delays: material is not available at the agreed upon delivery date (note that this excludes the situation of longer than desired delivery time).

(2) approval delays: longer than planned for interval to obtain plan approval or inspection from regulatory bodies.

(3) design/engineering/rework delays: either because the specifications are not finalized as soon as they should be or because of change orders.

productivity Problems. A productivity problem is defined as any practice or correctable situation which leads to less than full utilization of yard resources. Productivity problems can be further categorized as:

(1) labor practices: inflexible craft definition, unreasonable limits on overtime.

(2) personnel: lack of experience/high turnover, absenteeism.

(3) production methods: definition of work method; types and complexity of drawings; accounting for labor hours.

(4) scheduling: uneven production loads resulting in bottlenecks, schedule-induced delays, and underutilization of some resources.

Design Problems. A design problem is defined as any feature of the ship design which could be changed with resulting improvement in yard productivity and without materially affecting the economy of operation.

As we saw at the conclusion of the workshop, any number of general and specific programs can be formulated for alleviating these symptoms. The ones listed below in some cases duplicate those presented in the workshop. The intent here is to try to define general programs which have industry-wide impacts (thus are candidates for partial. support from MarAd) and which can be related directly to the list of "symptoms."

Standardization. This was mentioned many times by all three shipbuilding consultants. There are at least three distinct subprograms:

(1) Industry standards: a catalog of standard equipment and machinery, including technical specifications, interface specifications and envelope specifications. This obviously represents a massive undertaking and requires participation by vendors *as* well as shipbuilders.

(2) Design/Engineering standards: standard practices regarding elements such as straight vs. curved lines, standard clearances, *etc.* Such a program should involve not only the accumulation of "wisdom" from various sources, but also active design/engineing research and the involvement of the trade schools and universities that provide future designers and engineers.

(3) Production methods: similar to (2) above but focused on the actual production of the ship. This program should be broadly

defined to include not only the sequence of operations, but also the types of drawings provided, the definition of work packages, and the accounting, feedback, and control procedures. (Work methods and standard data programs are already underway through SP-8.)

Such an ambitious program of standardization could prove very expensive, and the magnitude of the benefits are difficult to foresee. However, the work methods programs sponsored by SP-8 are already showing positive net results.

Labor Productivity. This is obviously a sensitive area, but one that must be addressed if U.S. shipbuilders are to become competitive with the top foreign builders. Within this area, two subprograms suggest themselves:

(1) Work rules: some form of compromise with collective bargaining units is desirable *to* permit relaxation of overly restrictive work rules. This subprogram would develop a quantitative analysis and comparison of flexible work rules (such as those at IHI) and highly rigid work rules found in many U.S. yards.

(2) Employee involvement: this subprogram would provide management with the information needed to attack problems of absenteeism, low motivation, high turnover, poor work skills, etc. Basically, the program could begin by pulling together relevant results from the multitude of surveys and research projects that have already been done in this area.

A secondary consideration in addressing labor productivity is how yard management copes, in the long run. For example, it may simply be a fact of life that U.S. yards will suffer high turnover, thus, never build up the aggregate worker experience of, say, IHI. In that case, it would seem important to develop ways of coping, such as a production technology which doesn’t require so much experience and knowledge on the part of the labor force.

Regulatory/Approval Practices. This program would develop, in conjunction with the relevant regulatory bodies, “checklist” type guidelines. These guidelines would specify as precisely as possible, what is required, and at what stage it is required. It's probably the case that regulatory bodies are subject to the same types of workload fluctuations that many shipbuilders face. Thus, a second effort in this program could address the development of some mechanism for smoothing that workload. For example, in peak situations, a temporary or interim approval might be granted, subject to formal review within a specified period. It may also be possible for builders to "make appointments" well in advance for certain types of approvals or inspections.

Scheduling Methods. This program would address production scheduling as opposed to long range yard loading. There would be several phases to the program:

(1) Assessment: a descriptive analysis of current scheduling practice and a diagnostic comparison to scheduling practices in foreign yards such as IHI. This phase would focus on the kind of information used, the scheduling decision rules or techniques, the general quality of the results, and the" types of feedback and corrective action.

(2) Methods: a quantitative prescriptive analysis of the scheduling function focusing on the types and sources of information, appropriate scheduling methodologies (and computer aids), and operational requirements.

(3) Implementation: development of practical manuals for guiding the development of the scheduling function and the implementation of both manual and computer aided scheduling tools.

A key requirement in scheduling is the availability of accurate detailed estimates of work content and duration of each work package (as well as manageable work packages). These estimates could be based on experience and judgment, as is apparently the case at IHI, or they could be based on standard data. In either case, the large scale development of scheduling in U.S. yards depends on prerequisite development of the ability to accurately estimate work content and duration at a detailed level.

purchasing Practices. This program would be aimed at developing a more uniform purchasing function in shipbuilding. Two subprograms suggest themselves:

(1) Standardize PO Language: representatives from design, engineering, purchasing, and vendors would develop a standard format for RFB's and PO's to facilitate insofar as possible the timely definition of requirements and interfaces and timely delivery. This could also include standardizing the internal processes between design/engineering and purchasing.

(2) Industry Standards: this is the same as subprogram (1) under Standardization, but might be implemented on a smaller scale, focusing *on* the *most* common items which are frequently the source of acquisition delays.

Computer Applications. At the workshop, we saw one quite good presentation of computer applications in CAD/CAM. This program would be aimed at identifying" those computer applications (not limited to CAD/CAM) which have the best benefit-cost ratios. Some work of this nature is already being done by REAPS.

Summary The following figure describes the relationship between the proposed programs and the symptoms presented earlier. There are some omissions in the foregoing list of programs, such as, "establish central planning," or "increase preoutfitting." This was intentional, since these are tactical problems that need to be solved at the individual shipyard level. Hopefully, the programs described here all address strategic problems, which can be meaningfully addressed at the industry level.

CLOSURE

Up to now, this discussion has been pretty open-ended. In getting back to the original focus, engineering/production integration, it should be noted that the starred items in the following figure are particularly relevant. They each can be argued as programs which directly impact the efficient integration of the engineering and production functions.

Problems / Programs	Delays			Productivity				
	mtl.	approv.	des/eng/ rework	work rules	personnel	prod. meth.	sched.	DESIGN PROBS.
Standardization								
(1) Industry Stds*	X							X
(2) Design/Eng Stds*			X					X
(3) Prod Meth/Stds						X	X	
Labor Productivity								
(1) Work Rules				X				
(2) Employee Involvement					X			
Regulatory/Approval Practices*		X						
Scheduling Methods			X				X	
Purchasing Practices*	X							
Computer Applications	X		X			X	X	X

INITIAL ACTION PLAN

The formation of the design/production panel would provide a much needed forum for important design involvement in the work of the SNAME/Ship Production Committee. This is inherent in the concept of design being the initial stage of production. The interactive communication between planning, design and production would provide the basis for productive and usable panel output.

The panel is designed for the interaction of owners, governmental departments and agencies, design agents, universities and, of course, shipyards.

The following recommended tasks are based upon the work of the conference. The initial meeting of the panel would provide a consensus approval for the tasks to be undertaken.

Design for Production

- o Designing for producibility, as opposed to designing solely for performance or the owner, should consider two principal factors.
  - The individual shipyard facilities which cannot be addressed by the proposed panel.
  - Certain configurations which, regardless of the shipyard, are inherently more economical to construct.
- o The panel would undertake to produce an industry-wide consensus manual of economically producible design principles and practices with application to a case study for clarity.

Classification/Regulatory Body Approvals

- o Delay in approvals from regulatory agencies increases both the cost and time of the design/production cycle.
  - concentrating commercial ship regulatory approvals in one agency
  - defining the minimum information required and the preferred style and format of the information to be provided
  - identifying standard design elements or systems which could be approved on a one-time basis for on-going use
- o The panel would issue a report defining the consensus results of the feasibility studies in phase one. Work on viable approaches would follow-on in a phase two action plan.

Owner/Designer/Vendor Practices

- o Vendor delays in providing the equipment specifications, drawings and material itself cause significant delays and cost increases.

- o The panel should investigate the feasibility of utilizing more "off the shelf/out of the catalog" equipment as the design standards for shipbuilding as an alternative to attempting to impose unique "shipbuilding standard equipment" on the vendor.

Accuracy Control

- o Dimensional control to assure proper fit-up of piece parts, preassembles, sub-assemblies, units and blocks is essential for a productive operation.

- o Dimensional control begins in design and ends in production. IHI Marine Technology would be a consultant on this project with NNS as the lead yard. The project is currently under the auspices of SNAME/SPC Panel SP-8 Industrial Engineering. The MarAd Program Manager, John Mason,at Bath Iron Works concurs that the task is more appropriately placed with the design/production panel.

Change Control

- o Changes can be either costly or lucrative depending on the nature and point of view but in either case are normally disruptive.

- o The panel would investigate the types of changes, the sources of change and determine the feasibility and desirability of recommending the preparation of a change control manual.

York Packageq/Working Drawings

- o The information supplied at the work station is often inappropriate for the work to be done.

- o The content of the work packages, including the working drawings contained therein, are dictated only by the work to be performed not by the skill level, etc. of the worker. The panel would investigate the common features of an appropriate work package and publish a manual of standard practices.

Standard Nomenclature

- The documentation and reports on shipbuilding technology are difficult to comprehend due to the differences in terminology between shipyards.

- The panel should address the topic of standard nomenclature for published shipbuilding terminology. The objective would be to make the documentation comprehensible even though usage within individual shipyards may differ.

TECHNICAL PRESENTATION ABSTRACTS

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ENGINEERING/PRODUCTION INTEGRATION CONSIDERATIONS

Monday 0815 - 1000

Intershipping Consultants Ltd.
Sivert Jurud
Sigurdur Ingvasson
Rans Ohlin

Shipyard Engineering/Production Integration begins with advanced planning. Design must be production-oriented from early stages and technical feasibility considerations an integral part of early scheduling. Those technical constraints to scheduling include both those of ship design (engineering) and the shipyard (production). Advanced planning entails the coordination of engineering, material management, and production function, so that all departments work to the same initial schedule and follow-up adjustments during the building sequence from contract award to delivery.

Specifically, integration efforts on the part of engineering require the development of two sets of drawings - one set for design approval and another set of “working drawings” which are production oriented. Production innovations in the cause of integration focus on work preparation, detailed planning, dimension control, machinery and system control, and tank testing.

INNOVATIVE ANALYSIS OF COST-CUTTING OPPORTUNITIES

Monday 1015 - 1200

A&P Appledore Ltd.
Roger Vaughan

With special attention to the integration of design and production functions, a review of technological and organizational innovations that may be employed by shipyards to reduce building costs.

The presentation is based upon a study recently completed for the Maritime Administration's National Shipbuilding Research Program project, "The Development of a Standardized U.S. Flag Dry-Bulk Carrier". Phase II of the project addressed "Technology Development For Future Competitiveness" (Ship Production) while Phase I focused upon bulk carrier building cost and market projections. This study sets out the technological context within which the shipbuilder can consider his current production procedures and alternative building procedures, leading *to* a definition of the potential effect that these may have *on* the cost of construction.

TECHNICAL PRESENTATION
ABSTRACTS
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THE ENGINEERING/PRODUCTION INTEGRATION PROCESS: GRAPHICS, INTERACTIVE COMPUTING AND DATA BASE

Tuesday 0815 - 1000

Grumman Aerospace Inc.
Paul Wiedenhaefer

Historically the design and production of a product has centered around the blueprint, a parts list and manual calculations which insure proper design. Today, these three functions are performed with computer assistance including: graphic displays, a parts data base and an online, interactive computational system.

The presentation will describe how all three of these "sub-systems" are utilized at Grumman Aerospace and how they interrelate to each other, with special emphasis on the graphics design process. It will also show some actual results of the interactive graphics *system* as applied to the Grumman Gulfstream Transport.

TECHNICAL PRESENTATION
ABSTRACTS
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DESIGN/PRODUCTION INTEGRATION AT IHI

Tuesday 1015 - 1200

IHI Marine Technology, Inc.
Yosinobu Ichinose

During the past three decades, innovative approaches to improve shipbuilding productivity had been attempted and successfully implemented by Japanese shipyards. These advanced techniques, such as zone-outfitting, modularized unit construction, computerization in engineering and production, etc., have played a significant role in reducing the costs and times for engineering and production and, as a by-product, have contributed to improve the working environment, product quality and workmanship. The success of these developments were mainly attributed to the combined effort of the design and production engineering staffs which exchanged their needs and ideas to accomplish the projected goals. Needless to say, changes in familiar and accustomed engineering or production processes will usually need some concession on one side or the other, if *not* both, to attain an optimized solution.

Collaboration between design and production is not only essential in development of bilateral projects but also indispensable for smooth operation in routine production, such as production planning, scheduling, purchasing, work package sizing, etc. Therefore, a communication cycle between these two functions is considered as a pre-requisite to improve the shipyard's productivity.

This paper introduces the communication and information system between design and production functions applied in IHI and its implications in engineering, production and other factors that affect the efficiency of production.

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PRODUCTION/ENGINEERING INTEGRATION WORKSHOP

January 18 - 21, 1981

Atlanta, Georgia

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SHIPYARD ENGINEERING/PRODUCTION INTEGRATION

CONFERENCE AGENDA

January 18, 1981 (Sunday)

	Time	Place
Registration:	4.00 - 8:00 PM	Atlanta Room Lobby
Reception:	6:00 - 7:00 PM	Atlanta Room

January 19, 1981 (Monday)

	Time	Place
Registration:	7:30- 8:00AM	North Room Lobby
Opening Remarks	8:00- 8:15AM	North Room
Technical Presentation #1 Intershipping Consultants Ltd.	8:15 -10:00 AM	North Room
Break	10:00-10:15 AM	North Room
Technical Presentation #2 A&P Appledore Ltd.	10:15 -12:00 AM	North Room
Lunch	12:00 - 1:30PM	Belvedere
1st workshop Session	1:30- 3:30 PM	South A South B South C
Break	3:30- 3:45 PM	North Room
2nd Workshop Session	3:45- 5:30 PM	South A South B South C

January 20, 1981 (Tuesday)

	Time	Place
Administrative Remarks	8:00 - 8:15 AM	North Room
Technical Presentation #3 Grumman Aerospace Inc.	8:15 -10:00AM	North Room
Break	10:00 - 10:15 AM	North Room
Technical Presentation #4 IHI Marine Technology Inc.	10:15 -12:00AM	North Room
Lunch	12:00 - 1:30 PM	Belvedere
3rd Workshop Session	1:30 - 3:30 PM	South A South B South C

Appendix B

CONFERENCE AGENDA

	Time	Place
Break	3:30 - 3:45 PM	North Room
4th Workshop Session	3:45 - 5:30 PM	South A South B South C
Reception	6:00 - 7:00 PM	Assembly Room
Dinner	7:00 - 8:30 PM	North Room
January 21, 1981 (Wednesday)		
Panel Chairmen's Report to Plenary	8:30-10:15 AM	North Room
Break	10:15-10:30 AM	North Room
Speakers' Commentary	10:30-11:30 AM	North Room
General Chairman's Summary	11:30 - 12:00 AM	North Room
Adjournment	12:00 Noon	

ACKNOWLEDGEMENTS

Newport News Shipbuilding expresses its appreciation to:

The SNAME Ship Production Committee chaired by Mr. Ellsworth L. Peterson for approval to conduct this meeting under its auspices.

The Maritime Administration in the person of the Director of the National Shipbuilding Research Program, Mr. John J. Garvey, whose constant support and encouragement made the conference a reality.

ADI, a subcontractor of MarAd ably represented by Messrs. John Cartner and Michael Gaffney, who handled all the preparations, logistics, compilation of data, and made the general chairman's task pleasurable.

The presentors, assessors, workshop chairmen and all the participants, with their professionalism and dedication, made the meeting *an* invaluable learning experience and an outstanding beginning.

SHIPBUILDING DESIGN/PRODUCTION INTEGRATION WORKSHOP

VOLUME II

U.S. DEPARTMENT OF COMMERCE

MARITIME ADMINISTRATION

IN COOPERATION WITH

NEWPORT NEWS SHIPBUILDING

Proceedings of the Shipbuilding Design/Production Integration Workshop

Atlanta, Georgia

January 18 - 21, 1981

Under the auspices of the

Ship Production Committee

of the Society of Naval Architects and Marine Engineers

Volume II

INTERSHIPPING CONSULTANTS Ltd

2507 Red Oak Circle
Springfield, PA 19064

SWEDISH SHIPBUILDING TECHNOLOGY

CONTENTS

1. INTRODUCTION AND OVERVIEW

Introduction

When the concept of unit breakdown of the structural hull first started in the early sixties and shipyard facilities were dveloped to process those units, changes also were necessary in planning, design and material procurement.

With the new approach, cost estimating and follow up by construction numbers, which describes a functional part of the ship, *were no* longer adequate. To control the efficiency and use of expensive facilities manhours per unit was used and MTM-methods were implemented. The need for a planning function working with the unit concept was obvious.

To get the drawings and material to production at the start of fabrication of a unit, it was necessary to produce the drawings by unit and to specify the material by unit. This development within the structural hull was soon adopted also within the outfitting area when it became apparent that it saved manhours to preoutfit a unit instead of outfitting onboard. With these developments, more pressure was put on the planning, design and material procurement.

Planning

In order to coordinate design, material procurement and production, not only from a long term resource allocation point of view, but also from a technical point of view, an advance planning function was established. This planning works closely, together with Engineering, Material Managernent and Production in the precontract and early design stages before working drawings and production starts in an effort to minimize production cost.

In these early stages, target dates for each step for *a* unit are settled: what will be preoutfitted and when; when drawings and material lists are needed for each step; what information they will contain; and, when palletized material for each step must be available. This effort in the early stages to coordinate the different departments and make the design to fit the production is shown diagrammatically in Figure l and 2. Those tasks are not tied exclusively to an advance planning function, but it is important that they be performed and coordinated from somewhere in the organization.

The product from the advance planning is done in such a brief way that planning functions within Engineering, Materials Management and production have room for changes and alterations as the refinement and detailing of the work continues. Each activity in the schedules are identified by a planning number, see Figure 3. This number is the control instrument and appears on nearly all documents produced within Engineering, Materials Management and Production.

This planning number is the key for follow up activities by the advance planning function regarding manhours from production, drawing manhours and material status.

~~nts within Engineering, Materials Management and~~ Production use the result from the Advance Planning (see Figure 4) for short term scheduling and resource allocation.

The main responsibility for the detail planning function in Operations, for structural and outfitting work, is to define the different work scopes for the various shops and work areas, and to define budgets and schedules for each activity. Detail Planning is also responsible to develop the testing program for the entire ship. Performance monitoring and evaluation of all production activities is another responsibility of Detail Planning.

<u>Phases</u>

To explain the concept, it is of some aid to identify certain phases, as shown in Figure 5.

- Precontract:
- Phase I: This covers the period from after contract award until the functional design and the work of the advance planning function is completed. Most of the material is purchased in this phase.
- Phase II: This focuses on the preparation of the detailed design and completion of working drawings. Purchasing of common items with short leadtime is also done in this phase. Work packages and material lists for palletized material are identified.
- Production: From fabrication start to delivery of the ship.
- Follow up: Includes all follow up activities from staff meetings to follow up of manhours from production by Detail Planning and Advance Planning.

The primary difference between conventional shipbuilding and a concept with unit emphasis and preoutfitting is that much of what normally is done onboard is done as preoutfitting. This also impacts the testing and dimension control during the assembly stages. The result is short delivery times and low manhour budgets.

To accomplish preoutfitting and unit assembly Phase II is affected in that the working drawings must be done to fit the different steps of preoutfitting and unit assembly and must be issued earlier than in the conventional concept. Also, the material must be ordered earlier.

The impact on Phase I is that the functional design *must* be *better* defined to avoid problems later on and to enable material to be ordered. This leads to a better defined ship specification, where, already, specific vendors have been chosen for the more important equipment.

Design

Engineering is normally organized as in Figure 4. Engineering Development under Marketing consists of three groups: Naval Architectural Calculations, Estimating and Specifications. This department is responsible for coordinating the work until the contract award.

An example of how an Outfitting Department within Engineering can be organized is shown in Figure10. The organization method [redacted] Arrangements and Specifications, Systems Design, [redacted] taking *care* of the precontract and Phase I work, and a separate working drawing group performing Phase II work [redacted]. The Standard and Planning staff functions are also found in all departments.

The functional design is completed in Phase I and approved by the owner and the regulatory bodies. Very few, if any, of the working drawings and purchase specifications are sent to the owner or regulatory bodies for approval.

The working drawings are prepared in order to build the ship as easy and fast as possible. The drawings are made by unit or by area. They show each step of the assembly or outfitting process. [redacted]

[redacted]

Distribution of all information to Production occurs through a central distribution function within Engineering to a separate distribution function at Production.

<u>Material Administration</u>

A typical organization of Materials Management is shown in Figure 4.

The material is divided into two different types: direct purchased material to be applied only to a specific hull and stock material. The number of stock items can be as many as 6 - 10,000 depending on the type of ships and production, stock material is connected with the standards and material code books. The stock material is controlled and purchased by the Material Control department. [redacted]

[redacted]onsible through Material Control [redacted]

[redacted] The inquiries sent to the vendors leave them much latitude to come up with the best and cheapest solution to a problem before the order is placed; most of the detailed information is settled to avoid problems with vendor information.

Expediting maintains contact with Detail Planning in Production to make sure the expediters have the latest information about the production status *in* order to expedite the proper material.

The first step in receiving the material in the yard is to check that it is correct with regard to amount and quality. A special tagging system is used within the store room for material control, location, identifying and accounting.

For palletizing material for each work package, designated material locations are used. From Detail Planning each shop or *work site gets the* information with the work packages as to where the material is located. A special transport order is also included in the work package. A special addressing system is used throughout the shipyard.

General

The methods briefly described in this paper are used at the bigger Swedish shipyards such as Kockums yard in Malmoe and Arendal Shipyard in Goteborg. The methods were developed during the sixties and seventies and give a simple. and straightforward approach to the problem of reducing manhours within Production but also a more effective use of white collar personnel. Figure 6 gives an overview of tasks covered by those methods.

As the methods are proposed here, they are used manually, which makes them easier to fit into existing computerized methods. At the Swedish shipyards most of these methods, even within design, are computerized which of course gives a higher degree of efficiency but in some areas lesser flexibility.

As the methods are proposed here, they apply to any type of ship or products, piece or series production. The size of the yard determines how the methods will be applied.

SWEDISH SHIPBUILDING TECHNOLOGY

FIGURE 1

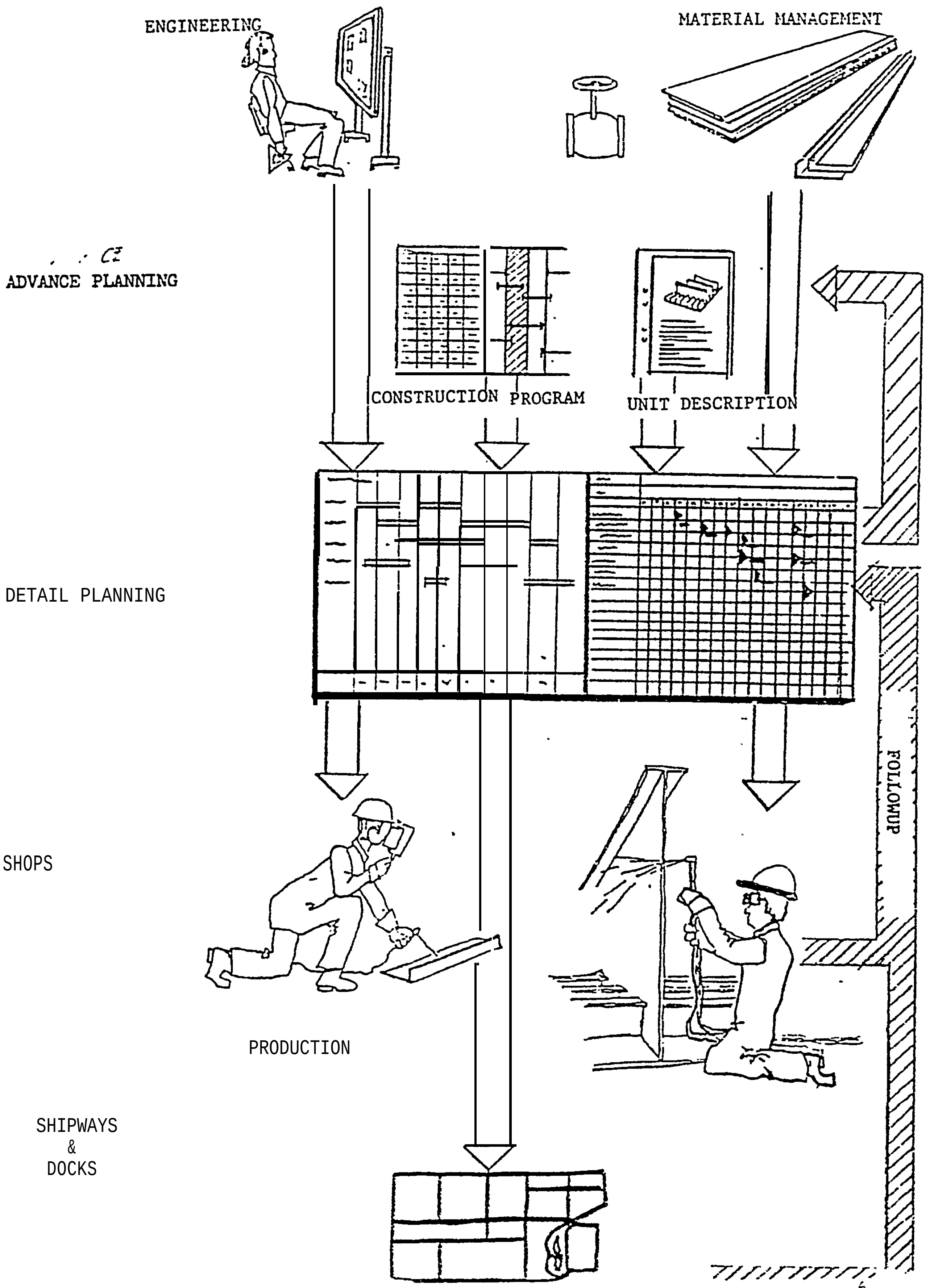
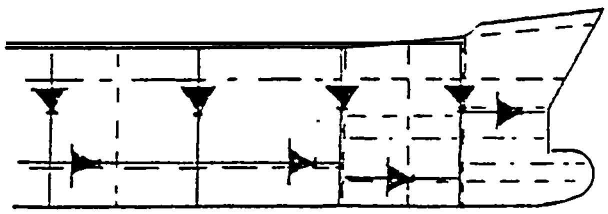
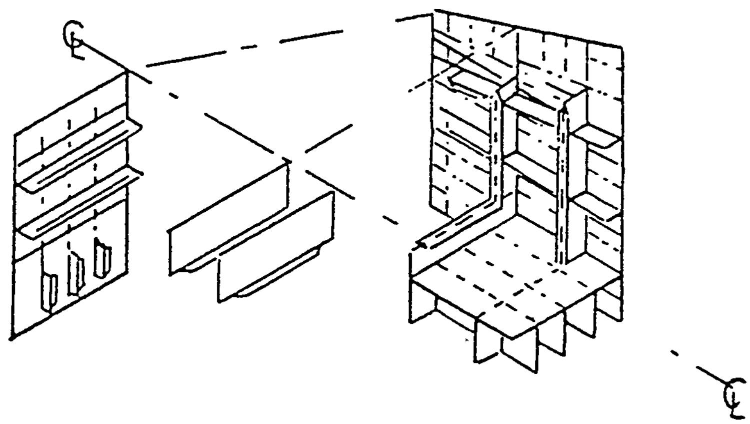


FIGURE 2



UNIT BREAK-DOWN



CONSTRUCTION TECHNIC

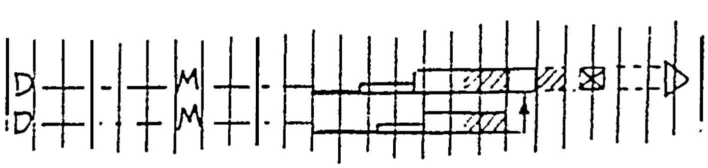
PREPARATION

A) BURN ALL PLATING FOR UNIT No XXXX
B) LAYOUT AND CUT ALL STIFFENER .....
C) ROLL PLATING FOR ......

SUB-ASSEMBLY

A) C.L. BULKHEAD
B) SLOPING LONG. BHD ...
C) LONGITUDINAL BHD ....

UNIT DESCRIPTION



TYPE PLAN

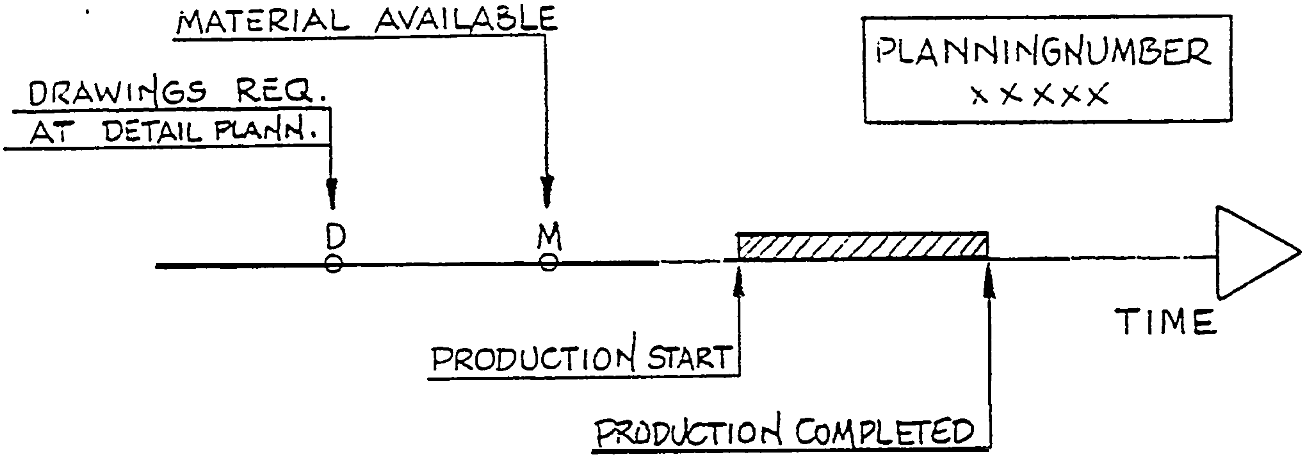
AS = ABOARD SHIP SLAB/WAY
AL = ABOARD SHIP AFTER LAUNCH

	DEPT. #	STR. #	DRAWING #	MAKE BUY	OUTFIT. LOC.	PLANNING #
LADDERS	13	918	3311-303	B/M	FS	33121
OTTOM PLUGS	12	793	3311 -			

OUTFITTING LIST

FIGURE 3

PRINCIPLE OF PLANNINGNUMBER



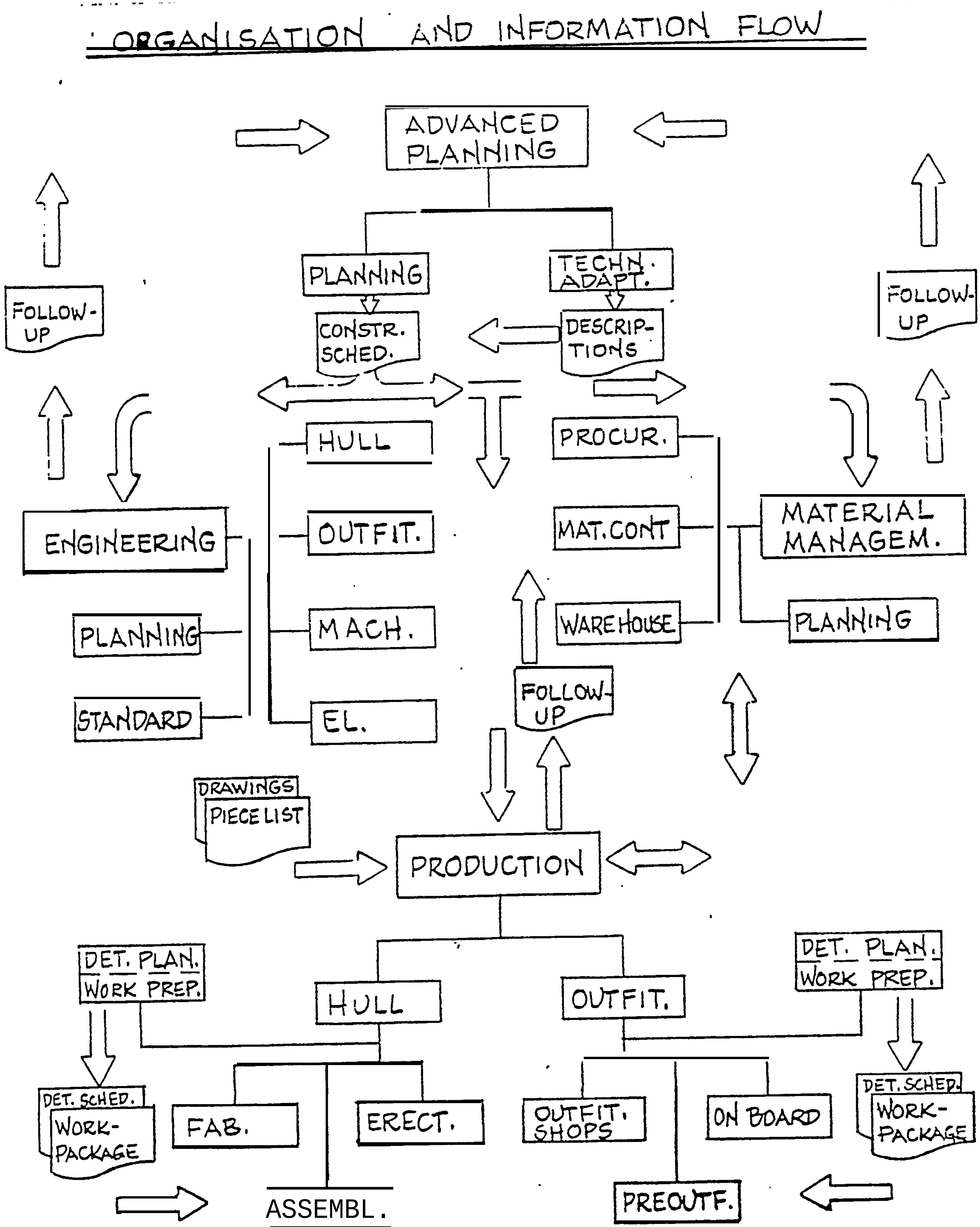
A PLANNINGNUMBER IDENTIFIES AN ACTIVITY IN THE SCHEDULE PRODUCED BY THE ADVANCE PLANNINGFUNCTION. IN THE SCHEDULE FOUR DATES ARE GIVEN FOR EACH ACTIVITY.

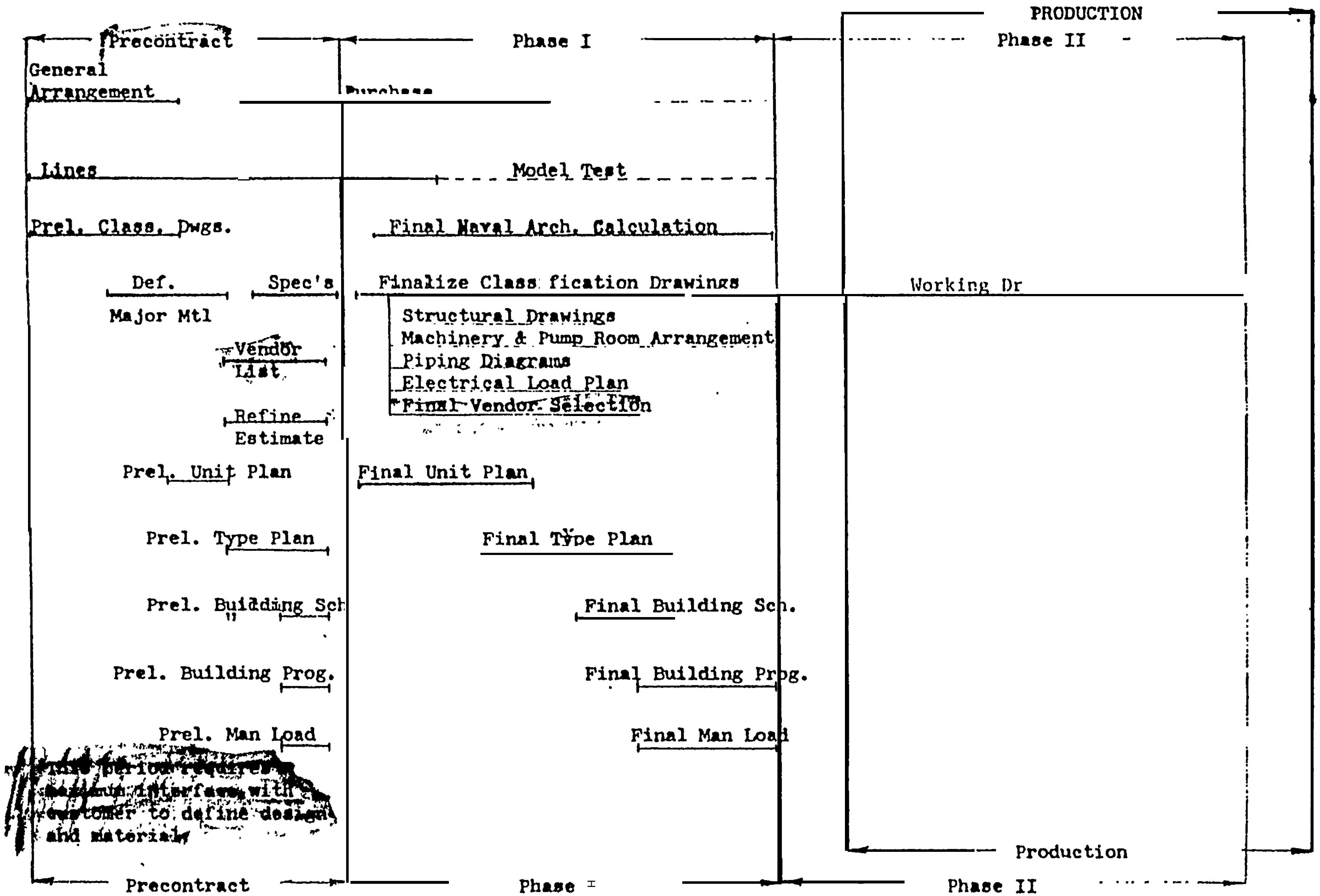
ENGINEERING HAS TO SUPPLY THE DETAIL PLANNINGFUNCTION WITH DRAWINGS AND BILL OF MATERIAL AT THE TARGET DATE FOR THAT ACTIVITY.

MATERIAL MANAGEMENT HAS TO SUPPLY THE YARD WITH THE MATERIAL FOR THAT ACTIVITY AT THE TARGET DATE.

DETAILPLANNING AND WORKPREPARATION BREAK DOWN THE ACTIVITY INTO WORKPACKAGES AND IDENTIFY INFORMATION AND MATERIAL NEEDED FOR EACH WORKPACKAGES.

FIGURE 4


ORGANISATION AND INFORMATION FLOW
ADVANCED PLANNING
PLANNING
TECHN. ADAPT.
CONSTR. SCHED.
DESCRIPTIONS
FOLLOW-UP
FOLLOW-UP
HULL
OUTFIT.
MACH.
EL.
PROCUR.
MAT.CONT
WAREHOUSE
MATERIAL MANAGEM.
PLANNING
ENGINEERING
PLANNING
STANDARD
FOLLOW-UP
DRAWINGS
PIECE LIST
PRODUCTION
DET. PLAN.
WORK PREP.
HULL
OUTFIT.
DET. PLAN.
WORK PREP.
DET. SCHED.
WORK-PACKAGE
FAB.
ERECT.
OUTFIT. SHOPS
ON BOARD
DET. SCHED.
WORK-PACKAGE
ASSEMBL.
PREOUTF.



Note: On any changes, the cost/time agreement between owners and Yard must occur one month after submittal to Owners. Yard has to define/justify change order impact.

TASKS

- MODERN SHIP DESIGN, PRODUCTION ORIENTED.

ORGANIZATIONAL APPROACHES IN ALL AREAS.

- METHODS FOR EARLY UNIT BREAKDOWN, SEQUENCING AND PREOUTFITTING.
- METHODS FOR EARLY SCHEDULING OF DESIGN, MATERIAL ORDERING AND PRODUCTION.
- LAYOUT OF WORKING DRAWINGS TO FIT PREOUTFITTING, OUTFIT PACKACES, AND PRODUCTION NEEDS, TOGETHER WITH ROUTINES FOR BILL OF MATERIAL AND MATERIAL ORDERING.
- LAYOUT OF DRAWINGS FOR REGULATORY BODIES ~~BOIDES~~ AND OWNERS.
- MATERIAL CODING.
- ROUTINES FOR RECEIVING, STORING AND DISBURSEMENT OF MATERIAL.
- MATERIAL CONTROL.
- TRANSPORTS.
- STANDARDS FOR DESIGN.
- PRODUCTION PLANNING AND WORK PREPARATION.
- DIMENS1ON CONTROL.
- TESTING PROCEDURES.
- STAGING.
- LAYOUT OF SHIPYARD OR OF INDIVIDUAL SHOPS OR AREAS.
- TECHNICAL AND ECONOMICAL EVALUATIONS IN ALL AREAS.

The Industrial Engineers then follow this up by measuring productivity with the old methods and with the new methods, so the effectiveness of the new can be determined. The overall tracking of the budget and schedule should be done by Production Planning together with Advance Planning. A typical detail planning function is shown in Figure 9.

Advance Planning - Technical Planning Department

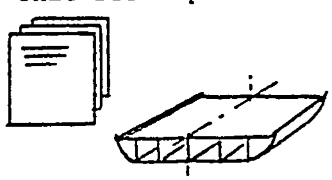
This function involves breaking down the ship into a series of units, determining the sequence of activities in the construction of the ship, describing each activity in a general way and preparing isometric drawings to describe the scope and sequence of each activity.

Technical Planning - Hull

Unit Breakdown

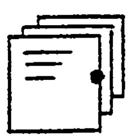
Divide the structure of the ship into units to fit the capacity of the shops or areas. The subdivision results in units which are similar in their fabrication characteristics. The units must be erectable so the ship under erection has sufficient strength to support itself and maintain its geometry.

Unit Description



Describe the fabrication process by which each structural unit will be assembled including isometric drawings.

Technical Planning - Outfitting



Outfitting list and descriptions. In cooperation with Engineering and Operations identify the significant items of outfitting material which will be preoutfitted in each structural unit or built as separate packages. Describe the method and stages of preoutfitting and how the packages will be assembled

Advance Planning - Planning & Budgeting

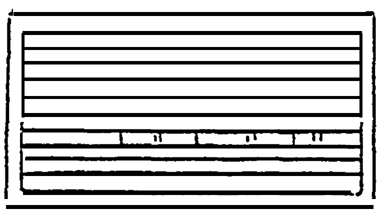
Budgets & Manpower	Manpower Budget - Determine the manhours required by each shop, area and craft for each month of the construction period.
	Manpower Requirements - Identify the number of men required in each shop and area by craft for each month of the construction period.
Type Plan	Produce a consolidated schedule in relative *time* which shows the significant events in the construction process and show the duration of the construction stages to each event.
Building Schedule Building Program	When the Type Plan is turned into absolute time it is named a Building Schedule. Produce a listing (Building Program) of construction activities which identifies the critical dates associated with each activity which must be met by Engineering, Material Management, and Operations in order to complete the ship on schedule.
Major Event Schedule	Planning together with management determines on the basis of economic and utilization considerations which Major Event Schedule program will apply in order to establish the safe times for keel laying, launching, technical trial run, and delivery for each ship.
Project Feasibility	For new projects check the availability of resources to support the project and develop manhour estimates.
Facilities Plan	Develop a long range facilities development plan (different alternatives) consistent with the types of ships the yard expects to build in the future.
Reports	Variance Report - Labor - Prepare periodic reports to identify variances in the actual labor hours used versus budgeted labor hours for detailed elements of-the construction process.
	Weekly Status Reports - Prepare a weekly report which identifies all known problem areas regarding schedule adherence and how to solve them.

Detail Planning

Principal tasks

The principal tasks for Detail Planning is to establish where and how production is to take place. For each ship the individual planning divisions together with production divisions develop a detail program. The *intent* is to control the production so:

- The load level (capacity/need) is as uniform *as* possible.
- Machinery and other equipment can be optimally utilized.
- Throughput times for details, parts, and units are as short as possib1e, and
- Short term storage and long term storage are arranged.



Planning also makes sure that parts of units or complete units can be delivered to the next station or shop, in the production chain, at the right time and with the best possible quality.

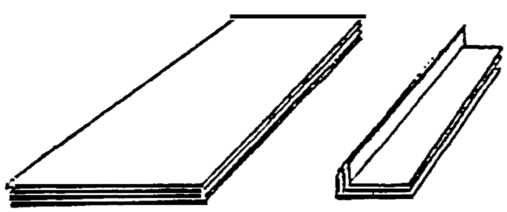
Production Planning is divided into:

- Work Preparation
- Detail Planning

Work Preparation

Work preparation consists of three groups:

- Work preparation *which* describes *where* the work is to be carried out.
- **Preparation for projecting the planned time anticipated per workscope and material order/material arrival for that workscope.**
- **Distribution: Order drawings, assemble and distribute work packages. Distribute** changes and drawing alterations.



The most important tasks of the work preparation group, are to:

The first part

- Provide a description of work which defines and illustrates for production as to where, how and in what sequence the workscopes are to be carried out.

- Set up the approval rules for welding together with welding engineers.

- Produce, together with production, material supplies for new ship types.

- Follow up in the work shops and help to rapidly examine and correct any deficiencies.

- Locate the fitting (access) holes and installation holes during the construction period.

The second part

- Describe the different operational sequences, for example, for plates and profiles, unit installation, etc.

- Calculate the plant time for each operation.

The third part

- Distribution: Drawings - Mark up, record and file all production documents (drawings, BM's, etc.) received from Engineering.

  Order drawings, assemble and distribute work packages. Distribute changes and drawing alterations.

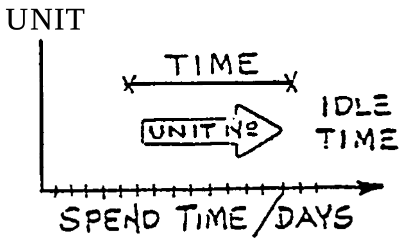
Detail Planning

Detail Planning is organized so one-individual per shop or area carries out all existing tasks. When the Building Program is settled, a more detailed program is developed. The first step is to evaluate the Type Plan from Advance Planning and in more detail carry out a detail erection schedule.

- After setting up the erection program for the hull units, this program is forwarded to the equipment planning department in order to include their activities during the ship construction time on the slab, shipway or drydock.

- This program now guides all other processing work in shops or areas.

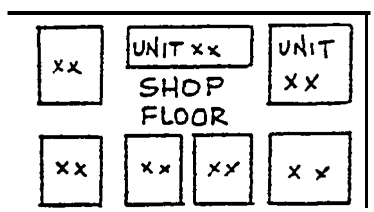
- The 'following explanation will describe how planning takes place, using an example from the fitting and welding work in a Hu1l Shop. For other shops and areas such as preoutfitting pipe shop, etc. in principal similar planning is carried out.



Throughput Time per Unit

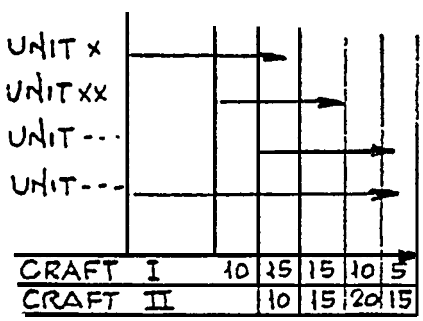
With the aid of the planned time (calculated time elapsed for a certain task), and as a result of experience and discussions, the time during which the section will lie in the hall before presented at the time needed by the next station, is determined.

Area Planning



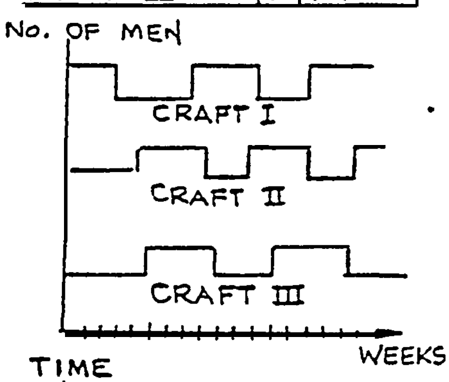
Each shop is, subdivided into a number of foremen’s areas. For the units planned in the respective areas, an area plan is carried out on a scale order to calculate the placement of the units. A new picture is presented for each change. The crane capacity and other important equipment for the respective shops are also taken into consider- ation.

6 Month Schedule



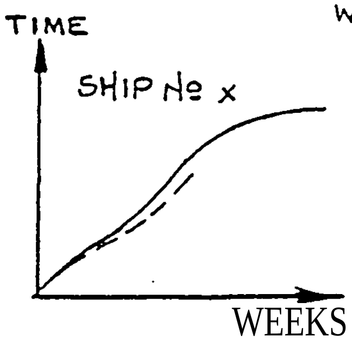
On a planning board for the respective foremen's area, units are now drawn in accordance to the respective time of need (outfitting, coating, erection) in order to obtain an overall occupational pattern of no more than six months ahead. For each week, the personnel requirement in each craft is calculated.

Total (Craft) Requirement



Since all areas within a shop or area are planned, the personnel requirement is summarized per occupational category to provide a total picture for each general foreman area six months in advance.

Time per shop, area and ship



A planned time curve is set up for each ship and for each shop or area. This curve is obtained by adding the times for each planned object per shop and per week, beginning from the previously developed occupation diagram.

Follow up - Final Reporting

Beginning from the planned program (area plans and time calculations) a follow up of the respective shop is carried out according to the following:

- Occupation times (starting and finishing) per unit follow the plan produced.
- Planned worker availability is achieved for each unit.
- Planned time output per unit is followed.
- Weekly Reports - Prepare a report which lists structural and outfitting activitiy which are not expected to complete on schedule, suggests corrective action, and indicates the expected completion time.

Precontract	Phase I	Phase II
Contract		
Estimating		
	"Class-Plans"	Engineer ng — "Working Drawings"
General Arrangement Lines Prel. Class Drawings Specification Major Mat. L. Vendor Lists Unit Weight Cost Calc.	- Model Test & Lines - Final Nav. Arch. Calcul. - Final Class - Drawings . Structural Design . Mach. & Pump Room Arr. . Piping Diagrams . El Load Plan - Final Arrangement - Final Vendor Selection - Final Unit Weight - Material Ordering - Miscellaneous Eng. Work	Pre-Outfitting - Outfitting Trial Delivery Contr. Delivery - Structural Working - Drawings with List of Material - Outfitting Working - Drawings with List of Material - Machinery Working - Drawings with List of Material - Electrical Working - Drawings with List of Material - Testing Information - Owners Drawing - Miscellaneous Design Work
reliminary: Unit Plan Type Plan Building Sch. Building Prog. Manloading Area Planning Misc. Planning Work	Final: - Unit Plan - Type Plan - Building Schedule - Building Program - Manloading - Hull Unit Descriptions - Outfit. Unit Descriptions - Isometric-Drawings - Testing Program - Facilities Schedule - Long Range Plans - Monitor performance to schedule and budget - Follow up and feedback	- Work content for ecah machine and craft/unit/shops - Manhour budgets for each machine and craft/unit/shops - List of materials for each machine and craft/unit/shops - Prepare work tickets authorizing the work to be done - Develop schedules, manloading and are covering (loading) for six months advance period - Distribution of all work-packages including drawings to workshops or work area - Budget monitoring on weekly basis - Monitor performance to schedule and budget - Weekly deficiency reports - Testing Program - Miscellaneous planning work
Precontract	Phase I ADVANCE PLANNING	Phase II DETAIL PLANNING

NAV. ARC. & ENG.

PLANNING

Figure 8

ADVANCE PLANNING

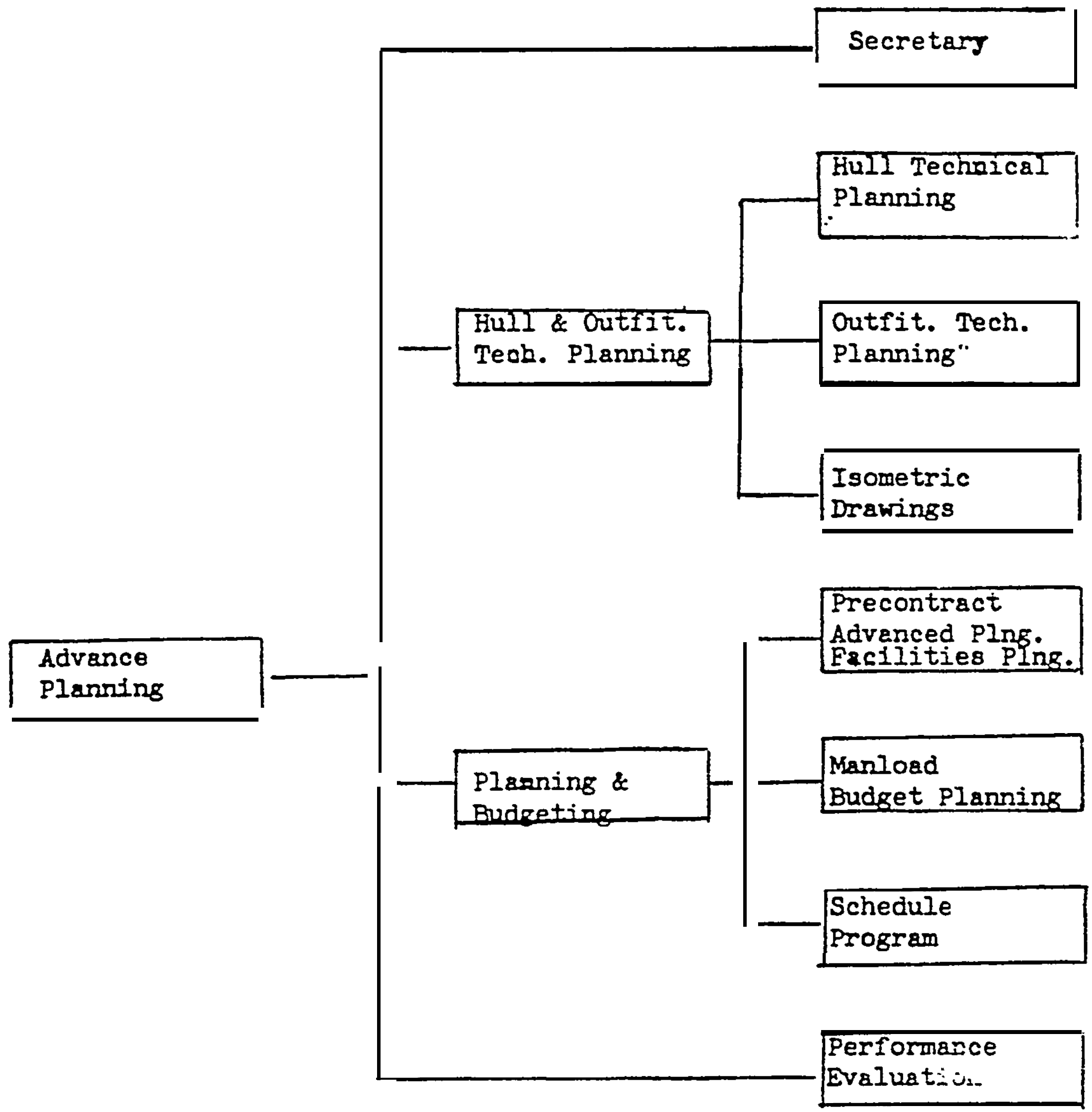
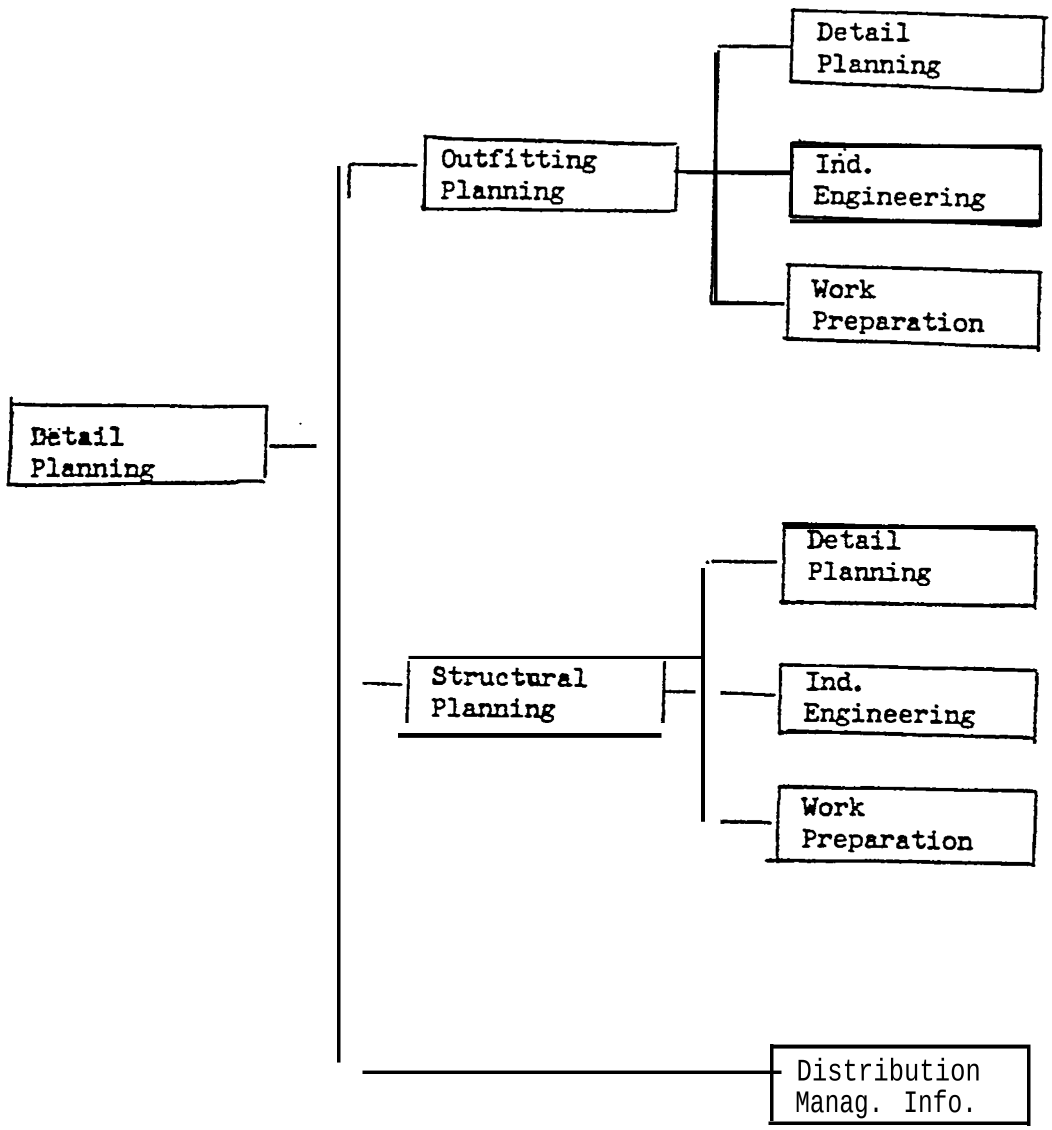


Figure 9

DETAIL PLANNING



3. ENGINEERING

Standards Function

A typical organization for an Engineering Department is shown in Figure 10.

Generally, the mission of the Standards function is to find and define standards, including ways of communicating design information as well as to define standard details so that the entire yard can easily follow the drawings. This function includes developing drawing formats as well as obtaining and providing information on production capabilities to the draftsmen.

Planning Function

The first task of the Planning function within Engineering is to work with the supervisors to set an Engineering schedule which supports the Building Program so that all Engineering information is available eight to eleven weeks before production is started in the shop. This also includes the planning of material requirements to be sure that material is available four weeks before work is started. For outfitting, Machinery and Electrical, an important aspect of this work is planning the timing of the flow information to and from the vendors. The next activity is to determine manhours required for each activity in the schedule. The third task is to total the manpower requirements for all projects in the department. Finally, the work to be assigned to each man must be identified. All of these plans and schedules should be tracked and repeated on a weekly basis.

Hull Department

The work of the Huli Department begins in the estimating or proposal stage. During this time, the department draws up and determines the scantlings of nearly all the basic design elements of the new ship. In developing the specification for the ship, there are two situations to be prepared for. If the Specification is done in the shipyard, the Engineering groups of the Hull Department writes the relevent parts of the specification. If the design originates on the outside, the entire design, including the Specification must be reviewed to identify improvements, changes or additions which will improve the ability of the shipyard to efficiently construct the ship. During this proposal time, there must be careful coordination and cooperation with Advance Planning and Detail Planning so that the design fits the production techniques. The design and the unit breakdowns then will be feasible from the design and production point of view.

After the contract is signed, the Hull Department will carry out the scantling of the entire structure in the first three to four months. They will continue to work with Advance Planning and Detail Planning to refine the unit breakdowns and accurately determine the weights of units. The class drawings are done at this point, area by area, with constant coordination with other Engineering departments to be sure that their requirements are accoummodated. The body plan must be developed along with the class plans in order to provide the information on the location of decks, bulkheads, seams, butts, longitudinals, and frames. As the class plans are completed, material orders are prepared.

The class plans are Sufficiently complete to accomplish several tasks. They must be sufficient to give the Owners, ABS, USCG and ocher regulatory agencies enough information for full approval, nearly eliminating the need for approval of working drawings. The class plans show seams, bevels, welding and structural details to give a high level of information to the working drawing draftsmen. The class plans also serve as an information and coordinating device for relations with other Engineering departments. In order to carry out their heavy role, the class plans contain structural standards as much as possible. Holes, penetrations and other detail items are included wherever possib1e. Another task of the Class Drawing group is the preparation of well defined test requirements for all structural testing: air, hydro or nondestructive, and all main dimensional control measurements for each unit.

The lofting process can be moved forward in the design process. It is desirable to start the lofting from the class plans and then give this information to the draftsmen for preparation of the working drawings. Th working drawings are done by unit but not finished by the draftsmen. The loft completes the drawings. The working drawings should give good, definitive information to production, but should not be used as the vehicle for internal Engineering information.

Outfitting Department

The Outfitting Department consists of the groups which perform all the design work related tc outfit items in the areas outside the Engine Room and Pump Room. As with other Engineering departments, they support bids and proposals by supporting the Engineering Technical division in its preliminary design and estimating work. The engineering part of the Outfitting Department also participates in understanding, writing or revising the ship specification. A major part of the work of Outfitting Engineering during the pre-contract phase of work is the engineering work and purchase specification preparation for items with long lead times such as hatch covers, ramps, elevators cranes, winches, and steering gear. Another responsibility in the pre-contract period is the development of coating information and the integration of coating application with the building technique.

After contract signing, the Outfitting Engineering groups amplify their pre-contract work in order to finally define the long lead items so that they may be purchased and vendor information can be obtained for other parts of the department on schedule. During the design period, Outfitting is responsible for holding Engineering together through maintenance of the General Arrangement. Outfitting is primarily responsible for systems such as ventilation, and fire mains, but shares in the development of systems such as the bilge and ballast system with the Machinery Department so that the whole system is correct. The Outfitting Department works so that the design is well defined by the purchase specification, with emphasis on having the proper information available in time to support the working drawings. Approvals from regulatory agencies must also be obtained on tired.

The working drawing group will provide all the information required by the shops through Detail Planning. Tine working drawings are done by unit or area to fit the preoutfitting stages. These groups are responsible for the following areas of the ship: deckhouse outfit, all ventilation, all pipe outside the Engine Room or Pump Room, all usual deck outfit, and the steering gear room.

Machinery Department

The Machinery Department consists of four groups which perform all the design work related to outfit items in the Engine Room and Pump Room. As with other Engineering departments, they support bids and proposals by supporting the Engineering Technical division in its preliminary design and estimating work. The engineering part of the Machinery Department also participates in understanding, writing or revising the ship specification. A major part of the work of Machinery Engineering during the precontract phase of work is the engineering work and purchase specification preparation for items with long lead times such as main engine and shafting, auxiliary equipment, boilers, cargo pumps, and other large machinery components. Machinery Engineering also prepares the Machinery Arrangement. The purpose of the Machinery Arrangement is to prepare for outfit packages and pre-outfitting, to identify space for the major ventilation ducting, major cableways and exhaust piping, and to allow consideration of the case of maintenance. All these items will be integrated at this early stage to obtain the best Engine Room at the lowest cost. Machinery Engineering also prepares the basic piping diagrams for all piping systems which have a major portion of their system in the Engine Room. Diagrammatic arrangements for the portions of piping systems in the Engine Room are done by Machinery Engineering. Another important precontract activity is the specification of the methods for engine automation.

After contract signing, the Machinery Engineering groups amplify their precontract work in order to finally define the long lead items so that they may be purchased and vendor information can be obtained for other parts of the department on schedule. The Machinery Department controls the Engine Room through the installation drawings (composites) which allow the identification of interferences and the reservation of proper space for all items. During the design stage, it is important that the vibration calculations be a part of the iterative process of designing the shafting and stern. The design of the main engine room automation system is done in the Machinery Department. As with other departments, the Machinery Department cannot work alone. It must work with all departments, drawing support particularly from the Electrical and Outfitting Departments. The Machinery Department works so that the design is well defined by the purchase specifications, with emphasis on having the proper information available in time to support the working drawings. Approvals from regulatory agencies must also be obtained on time.

The working drawing groups will provide all the information required by the shops through Operations Planning. The working drawings are done by area to fit the preoutfitting stages. These groups are responsible for the entire installation of the Engine Room and Pump Room. They also are responsible for special design items such as shafting, cranes, outfit packages, ladders, gratings, and any detailed structure required for the installation drawings. For these special items, they provide “vendor” information to the rest of Engineering for items which are designed and fabricated in-house.

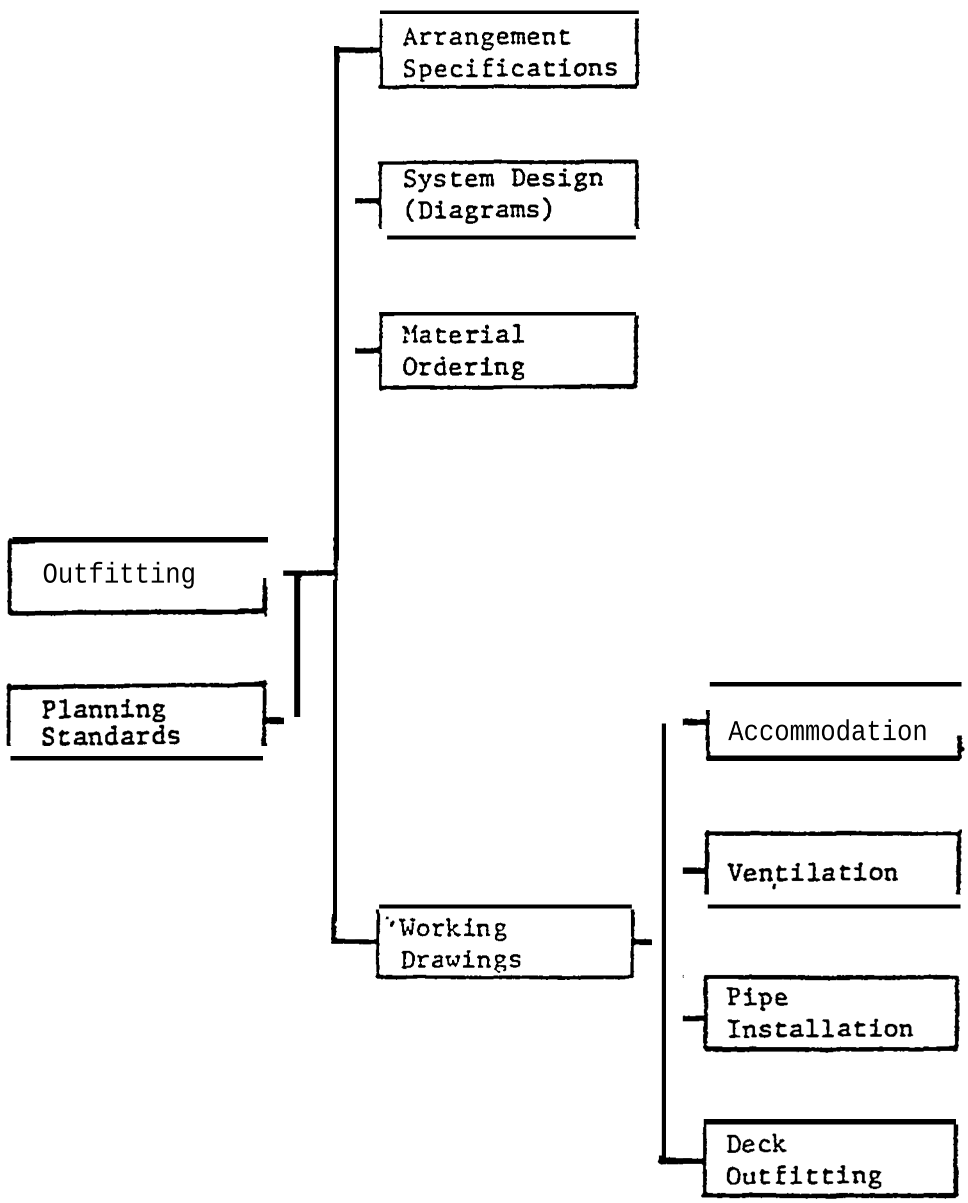
Electrical Department

The Electrical Department consists of groups which perform design work for electrical systems and for automation of electrical systems throughout the ship. They also support bids and proposals by supporting the Engineering Technical division in its preliminary design and estimating work. The engineering part of the Electrical Department also participates in understanding, writing or revising the ship specification. A major part of the work of Electrical Engineering during the precontract phase of work is the engineering work and purchase specification preparation for items with long lead times such as switchboards, generators, motors, special cables and special instruments. An important item for Electrical Engineering is to prepare the electrical load analysis calculation before the estimate is started. It also is necessary to have the electrical one-line diagram for the system ready before the contract is signed.

After contract signing the Electrical Engineering groups amplify their precontract work in order to finally define the long lead items so that they may be purchased and vendor information can be obtained for other parts of the department on schedule. During the design period, the Electrical Department is responsible to keep the electrical power diagrams up to date so that others will know where cables are located. They also provide information to other departments so that cableways can be planned. The Electrical Department works so that the design is well defined by the purchase specifications, with emphasis on having the proper information available in time to support the working drawings. Approvals from regulatory agencies must also be obtained on time. In preparing purchase specifications, only the necessary performance items should be given, leaving the internal details to the vendors’s proposal.

The working drawing groups will provide all the information required by the shops through Operations Planning. These groups are responsible for all electrical work in the ship. The work should be well defined so that electric equipment and cables can be installed in the preoutfitting stage of units or blocks wherever possible.

TYPICAL ENGINEERING ORGANIZATION



4. MATERIAL ADMINISTRATION

Engineering

Prices

The cooperation between Purchasing and Material ordering groups within Engineering is very close. To evaluate the quotes from the vendors it is necessary for Engineering to have information about estimated costs, offered or quoted prices and final material costs. For the best efficiency Engineering ought to be responsible not only for the cost of the material but also at the same time for the cost of surplus material.

Purchase, naturally, is always responsible for purchase of the material and for the contacts with the vendors, but gives Engineering the information for a technical-economical optimization.

Quotations

An early request for quotations can consist of:

- Handwritten description

- Old Purchase Order, eventually with amendments

Purchasing decides how the quote will be formalized and they also issue it. As a first step, this early quote will be sent to a great number of vendors. Engineering chooses, in cooperation with Purchasing, either two or three possible vendors and negotiates further with those before the final selection. In this negotiation, the details of the technical, economic, and schedule elements are determined. When the order is placed, it becomes a contract that the material must be at the yard at the date agreed upon. No "release for manufacture" or "promised delivery dates" exist. All vendors are carefully evaluated for quality, timing, and prices.

Material Supply

There are two ways to supply production with material:

1) from stock

2) buy from outside

If an item of material is often used unplanned and is relatively cheap, it should be stock material. Stock material saves a lot of work for Engineering and Purchasing but costs, at the same time, money to keep in stock.

If a material is used not so often, its use is planned and relatively expensive it should be bought from-outside when it is needed.

The stock material consists of 6 - 10,000 different items depending on ship types and production pace. The Standard Department and Material Control Department make the decision about what items to have in stock.

Purchased material is requisitioned by Engineering. All material has a material code, which Material Control is responsible for maintaining.

Surplus

All purchased material has an ordering department as the responsible department. That means that the ordering department number should be - registered together with a purchase order. When a hull is delivered a list of surplus material is printed. After a physical inventory a new list is printed for every department which has surplus material.

The department must decide if the surplus material should be -

- scrapped out
- reserved for another hull number
  saved as surplus material for x number of years

Every year a list printed for each responsible department. This list contains -

- amount of value scrapped out during the year
  amount of value reserved split up per hull number
  amount of value saved as surplus split up on the year it was purchased

Material Control

Stock control

At an early stage in the design, Engineering makes reservations of stock material by structure area and required date. Those are later on checked against the piece list (Bill of Material). This information contributes to the possibility of having a small stock with a big service level.

To be able to calculate EOQ according to the Wilson formula Material Control must have information about costs for a purchase order, stock keeping costs and up-to-date lead times for different kinds of material.

Pricing of material is done by Material Control which receives price information from the purchase orders and also calculates disbursement prices for the disbursed material.

To make it possible to govern the stock levels in an active way,

- New items must be controlled when they are implemented in stock.
- Stock items must be controlled on a yearly basis.

Warehouse

Receiving Routines

Receiving cards are produced when a purchase is made. The receiving cards consist of the following parts:

- Report card for material control
- Guide card for store location in Store
  Identification card for tagging of material

The Receiving card is filed on:

Purchase Order number
Hull number
Material code
Delivery date
Structure

Engineering, on Requisition to Purchase, makes notations if they want to take part in the receiving control.

Disbursements

(1) 2 to 5 weeks before the planned start of a job in the work shop, printed:

material requisition
transport card
- identification card

for every line in the piece list. (BM's)

These cards are sent together with job tickets, drawing, material list and operation list to work shop office.

(2) About 1 week, minimum 3 days, before the start of work requisition, transport and identity card are sent to the storeroom for disbursement of material.

(3) For contract material, information about store location is taken from the guide card where, also, disbursement notations have been made.

(4) Material is delivered to the desired transport address by the Transportation. All material which leaves Stores is tagged with two cards:

- Transport card
- Identity card

(5) The requisition is completed with' notations about disbursed quantity and after that sent to Materials Control.

Material Areas

To make it possible to assemble material for different work packages, material areas are arranged in the storeroom. Decision about storing material on material areas are made either from Work Preparation or from the shop office. The location is given on the requisition cards by a special transport address. The following materials are directed to Material areas:

- stock material
- contract material
- internally manufactured material

Only if the size, weight or form makes it difficult to handle is material not sent to the Material Areas. If possible, all of the material should be put together in order to make the disbursement job easier.

For material stored on a material area, **a notation is made on the transport** card about what Store location is used. After that the transport card is sent to the work shop office as information that material is available.

When material is requested, either the transport card is sent over or personally handed over to material area administration with a notation about the new transport address. The material is then delivered to the wanted transport address by the Transportation.

Transports

Addressing

The yard can be divided into ten (10) zones, each zone into ten (10) areas and each area into a maximum of 99 "squares".

An address can look like this:

1	2	3 4
zone	area	square

Ihe addresses are to the greatest possible extent, physically given through painting and signs. An address system is important for the Work Preparation groups which will assign transport addresses to the work packages.

An address system will improve the speed in the transport system. Truck drivers do not have to look for material which will be transported and receivers of material know where to find the material.

Requisitions

Requisitions together with work tickets and drawings are kept in starting weeks order. When starting week is close the requisitions are sent to the warehouse which disburses the material and sends it to the requested transport address. If that transport address is a material square, the transport card returned with a notation about store location. If another transport address is used, the expediter from the work shop office must receive the material, take off the transport card, and make a notation about the exact location. All transport cards are kept together with drawings and tickets and issued to the supervisor when the job is close to start. Material can after that be called off/localized with help of transport cards with notations about store locations.

5. CHANGE PROCESS

In order to have a smooth transition from present methods to new methods, it is essential to form an organization to manage the transition. This organization must have, within it, well defined task groups. These groups would be composed of members of management and specialists in various areas, Design, Planning, Production, Materials and Human Resources must all be represented.

The recommended structure of the transition organization is shown below

Overall Transition Coordination Committee

President
VP - Operations
VP - Engineering
VP - Personnel
Transition Coordinator

Consultants to the Management

Organization Development Guidance Committee

VP - Human Resources
Labor Relations
Training
Engineering Representative
Operations Representative
Transition Coordinator
Consultant

Technology Guidance Committee

VP - Operations
VP - Engineering
Director - Planning
Consultants
Transition Coordinator

The transition organization shown above will carry out the transition through task groups. Working within the framework of an overall plan for making the transition to the new techniques, each task group will be formed to accomplish a specific action within a specified time frame. The task groups will work with the existing organization to solve the problem and make the new techniques and solutions a part of the working practices of the organization

6. COST BENEFIT

If all the actions recommended by us are accepted and implemented by the organization, the cost benefit will be as follows:

	Reduction in Production Manhours
- Impact of improved design and material techniques	15 - 20%
- Impact of planning methods	10 - 15%
- Impact of improved control of work and work relationships	10 - 15%
Total Benefit	35 - 50%

It is difficult to exactly assign the benefits to a specific part of the shipbuilding process or to a specific part of the organization. The implication in this is that no single change can be accomplished in isolation. A new technique or working practice in one area will result in maximum benefits only if related changes are made in other areas.

It also is essential to begin the change process in the right way. For example, unless the design is properly adapted to the production methods, no real planning can be done. Or, if the material is not defined in time, the material will not be available in time and production cannot be done efficiently. As a guideline for the benefits to be gained, we can compare manhours in European shipyards with manhours in typical American yards, for a relatively simple 25,000 DWT cargo ship.

When calculated on the same basis used in American yards for determining manhours per ton, the relevant European figures are:

Structural	20 manhours/N.S.T.
Outfitting	10 manhours/N.S.T.
Staging, Cleaning and Painting	3.5 manhours/N.S.T.
Transportation and Services	2.5 manhours/N.S.T.
Total	36 manhours/N.S.T.

The figures will vary from ship type to ship type, but the basic results remain the same. In a cooperative, open environment, progress toward this level of man!lours can be noticed in the first contract to which it is applied. The full benefit should be achieved, under these condition, in three to four years.

METHODS OF REDUCING COST THROUGH ENGINEERING/PRODUCTION INTEGRATION

BY

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NORTHUMBRIAN WAY

NEWCASTLE UPON TYNE, U.K.

JANUARY 20, 1981

METHODS OF REDUCING COST THROUGH ENGINEERING/PRODUCTION INTEGRATION

1. Introduction

The aim of this presentation is to examine the technological alternatives available to the shipbuilding industry with the object of identifying ways of improving productivity, reducing non-productive man-power expenditure and reducing the ship production cycle time.

Reduction of ship construction time can lead to significant direct and indirect cost savings. Ship construction time in most US shipyards is perhaps two to three times longer than that found in modern shipyards outside the US. The application of methods which improve productivity and reduce construction time is therefore of great importance in achieving economic construction.

2. Factors Affecting Productivity

There are many factors which affect productivity but there are five main headings under shich the factors can be grouped. These are:

a. The Product - By this is meant the extent to which the ship is designed for ease of production in a particular facility. This will include consideration of the structural breakdown; steel, outfit and engineering arrangements; production engi-neering - simplification, standardisation and group technology; value engineering; standards application; construction sequence and so on.

b. The Facilities - The physical arrangement, capability, capacity and efficiency of each element of the production system.

c. <u>Shipbuilding Techniques</u> - The extent to which the best modern steelwork manufacturing, outfit production, ship construction and outfit installation, and materials handling and storage methods are effectively applied within the physical constraints of the shipyard.

d. <u>Organisation and Systems</u> - The extent to which the best appropriate methods are effectively applied to the following activities: process and production planning, production of technical information, organisation of work, production scheduling and control, purchasing and stores control, quality and dimensional control, etc.

e. <u>The Workforce</u> - Including effective hours, incentives, job satisfaction, motivation, abour skill, working practices, safety and welfare, working conditions, working environment, etc.

3. <u>Comparative Productivity Study</u>

A brief productivity assessment study was undertaken by A&P Appledore in order to measure the difference in performance between typical US commercial shipbuilders and good comparable foreign shipyards in examining the potential construction of bulk carriers.

The results of the study confirmed what is generally accepted in shipbuilding circles. That is, that productivity in the best Japanese and Scandinavian yards is of the order of 100% better than in good US or UK shipyards.

The next part of the study was to determine what approximate proportion of this difference is due to The Facilities and Shipbuilding Techniques and what is due to other factors.

It was possible to estimate the effects as follows:

i. The Product

25-30% of the difference in productivity between the typical US yard and good foreign yards can be accounted for by more detailed design for production in the foreign yards.

ii. The Facilities and Shipbuilding Techniques

35-40% of the difference can be accounted for by better layout and facilities and by the application of advanced shipbuilding techniques in the foreign yards.

iii. Organisation and Systems and The Workforce

30-35% of the difference can be accounted for by better organisation of work and systems and in some cases a more effective workforce in the foreign shipyards. This means that the greater part of the difference is not related to heavy capital expenditure but to greater attention to producibility, plannihg and engineering/production integration.

4. Production Technology

Over the past few decades, developments have taken place which allow ships to be produced more efficiently and in an environment which allows a greater level of control and a higher degree of accuracy and quality of the finished product to be achieved.

Contemporary shipbuilding technology incorporates a large degree of prefabrication. Recognizable elements of ships are manufactured in workshops with all the inherent advantages which this provides. Manhour expenditure during erection - the last shipbuilding assembly stage, is minimised by the effective transfer of work from the building dock or berth to the steelshops.

The ship construction process remains abour-intensive. Two objectives in achieving efficient construction are apparent. The first is to reduce the work to be complete at the final construction stage, the second is to use the best methods available to complete such work as must be done.

Emphasis must be placed on accuracy of components and on the production of large natural units. These reduce the balance of work to be completed at the construction stage and reduce the difficulties in fairing steel units and blocks.

The transfer of work from the construction stage to an earlier stage in the shipbuilding process has five main advantages:

a. Work carried out in the workshops is easier to plan and control than work carried out on the ship,

b. The workshop can be equipped with the appropriate purpose-designed production, services and handling equipment.

c. Access for workers and supervisors is more convenient.

d. The maximum amount of work is completed under good environmental conditions.

e. Overall material handling and manpower movement requirements are reduced.

Not only is it more economical to transfer work from the construction stage to an earlier stage, but also it leads to reduced construction cycle times.

5. Cost Generation

In studying hOW reducibility (an assist in cost reduction it is useful to define how costs are generated.

COST CONTROL POTENTIAL

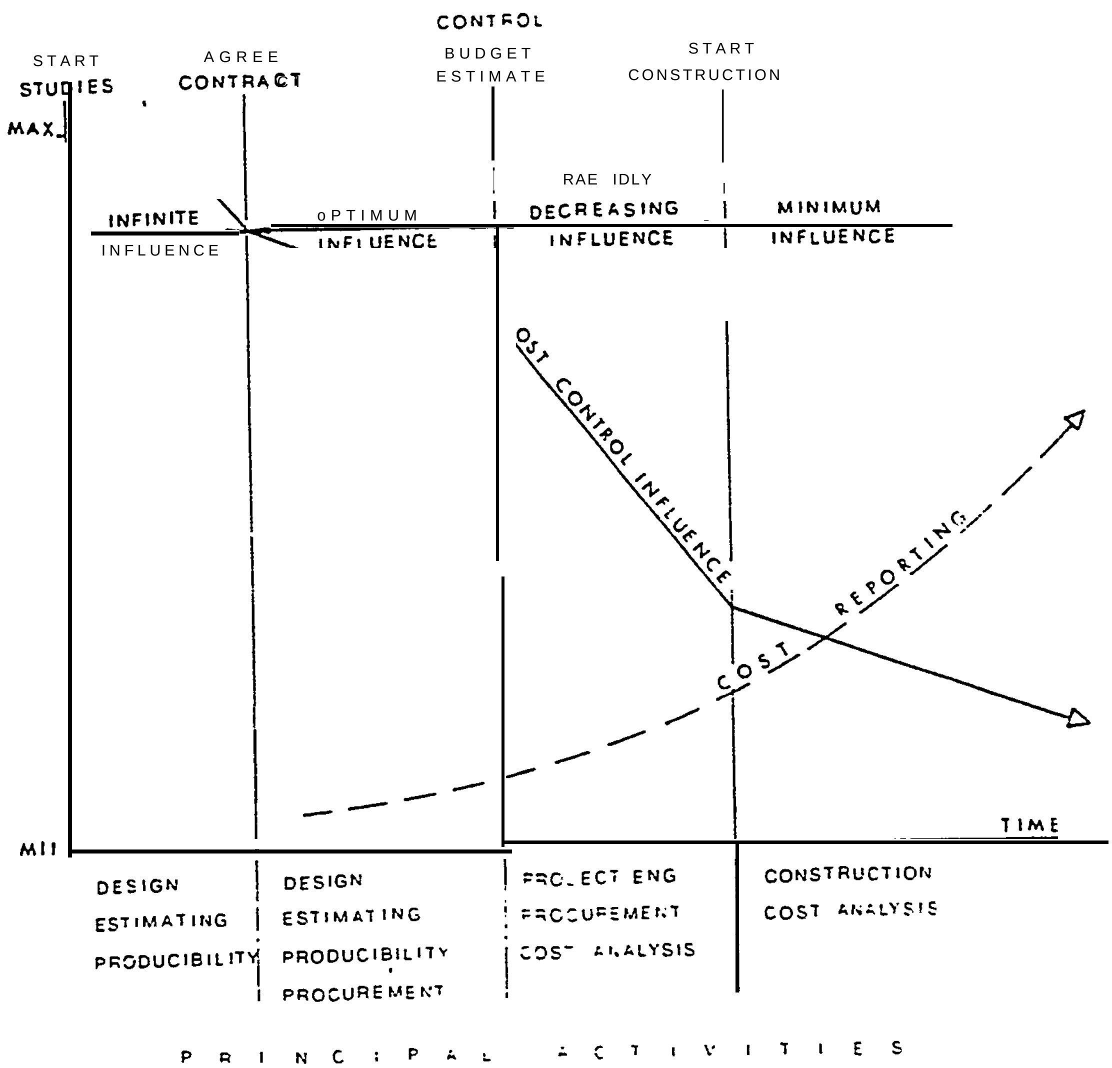


FIGURE 4.1

Responsibility for generating the cost must be explored. In the context of contract cost control there are three factors to consider:

- the estimated cost.
- the estimated time.

the measurement of value of work done in relation to the estimated cost and the estimated time.

Given these three parameters it will be appreciated that cost reporting in itself is not enough. There must be progressive control of cost generation. This can be exercised through three stages:

authority to approve expenditure.

comparison of commitments with estimates.

comparison of actural work done over time with the estimated work done over time.

Considered in this way it can be seen that the ability to affect and control costs diminishes with time. This is illustrated in Figure 4.1.

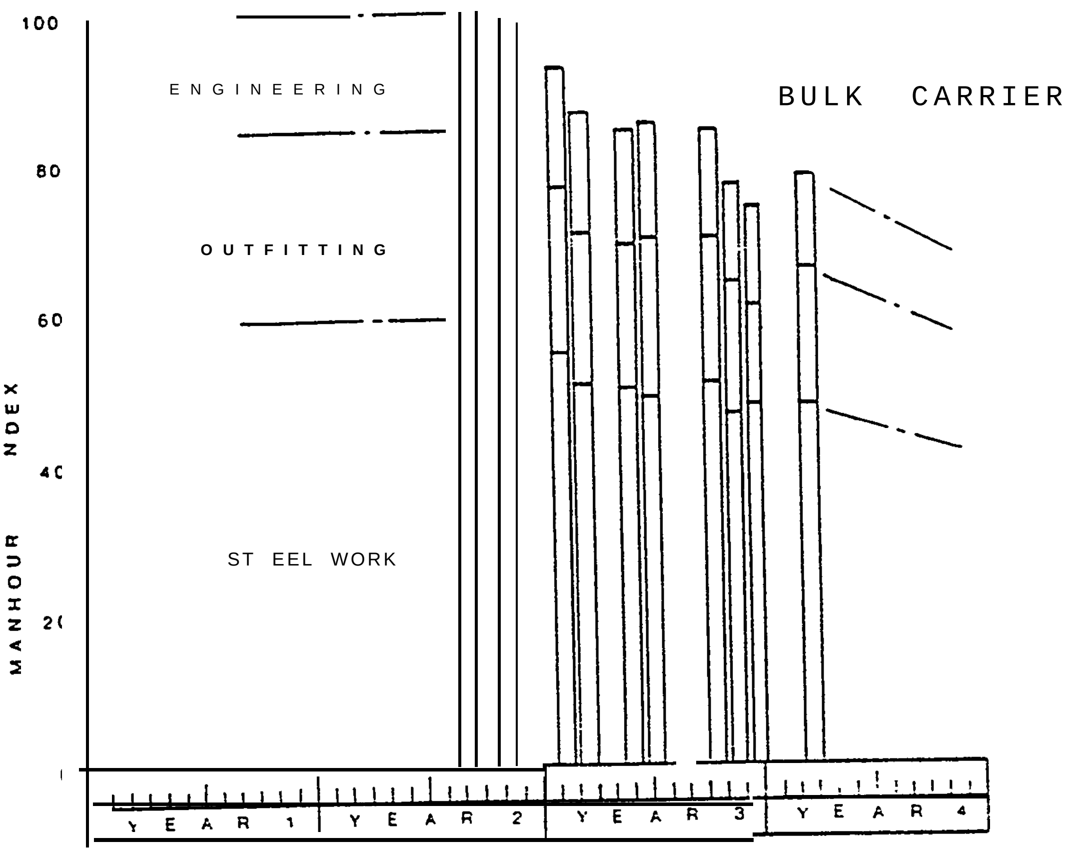
This diagram shows that up to the signing of the contract there is an infinite influence in the determination of costs. While vessel types vary, one would expect a variation in estimated cost because of perhaps significant differences in specification. So, in writing the specification, the shipowner and the shipbuilder are fixing the cost of a ship within a price bracket. At this point in time there is a high degree of cost commitment, not only in material specification but also in quality specification. It is at this time that productibility should first be considered.

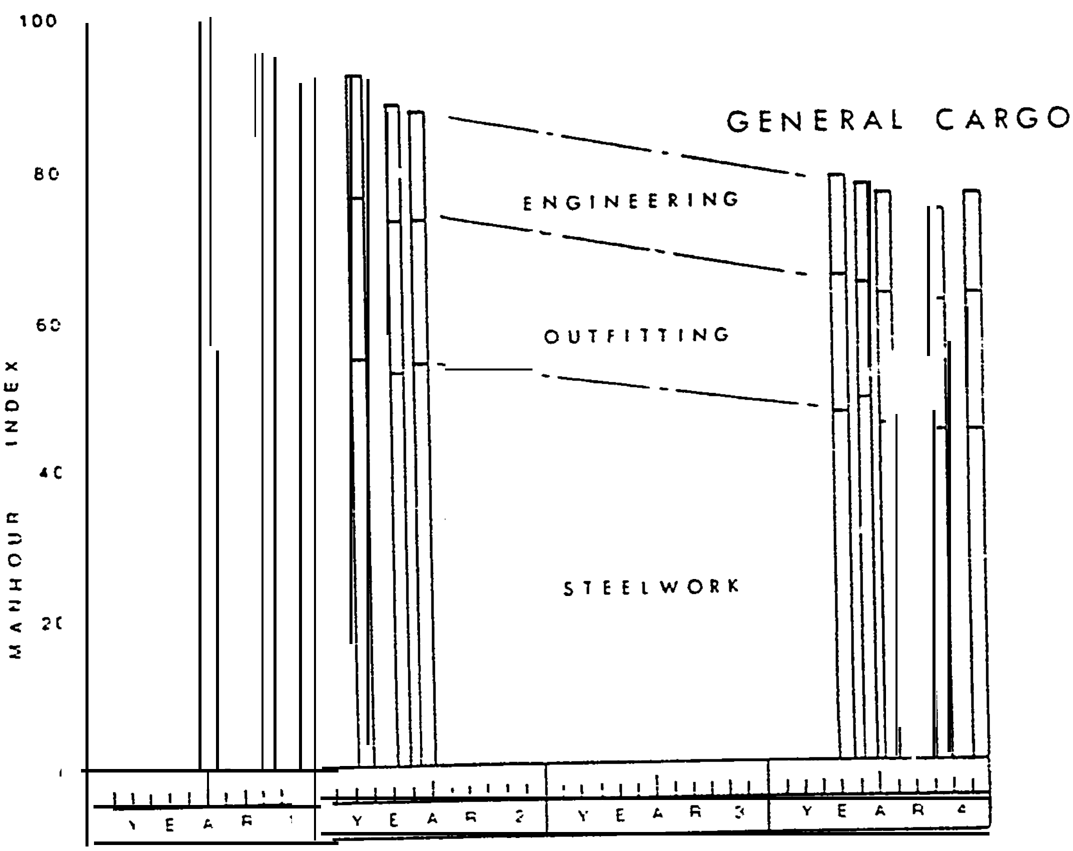
After contract signature, when the definition of the contract is agreed through the specification, there is a period where there are opportunities for cost control and reduction. During the stage of contract development, detail design and material ordering, important opportunities are afforded in the form of establishing the construction philosophy and developing production methodology, as well as selecting subcontractors and materials at lowest cost. It is not always appreciated by technical staff that in setting out details on a drawing they are not only committing material costs but also labour costs, as the manufacturing and assembly method is fixed to a high degree by what appears on drawings. This also applies to other costs such as jigs, tooling, access platforms, the need for which can often be avoided by better design with respect to production. Producibility considerations are most influential at this stage of the contract in the form of cost commitment.

As the design phase finishes and the construction phase commences there is arouud 20% of the total ship cost still to be committed in the form of direct labour, materials and equipment. This is normally the time when increasing cost control is employed, when around 60% of the contract cost is committed and there is little left to control.

To examine the effect of a multi-ship order in which producibility is introduced, a comparison is made with a UK shipyard which has progressively introduced improved methods of construction to reduce costs. This was done over a period of three and a half years while the shipyard was building two standard vessels, a general purpose cargo vessel and a bulk carrier. Since the vessel designs did not change, except in detail, virtually all of the reuction in manhours is attributable to producibility. On the bulk carrier the keel lay to completion time was reduced from

FIGURE 5.1


100
80
60
40
20
0
MANHOUR INDEX
ENGINEERING
OUTFITTING
ST EEL WORK
BULK CARRIER
YEAR 1
YEAR 2
YEAR 3
YEAR 4


100
80
60
40
20
0
MANHOUR INDEX
GENERAL CARGO
ENGINEERING
OUTFITTING
STEELWORK
YEAR 1
YEAR 2
YEAR 3
YEAR 4

47 weeks to 28 weeks during an 18 month period. The reduction in direct manhours achieved was 25.9% on the general purpose cargo vessel and 28.3% on the bulk carrier.

These manhour reductions were a result of improved block breakdown, pre-outfitting to around 70% of what is ultimately expected, modular assembly of equipment and changes in working practices which allowed final chocking of the main engine prior to launch. The reductions were not uniformly distributed and many departments had major savings as constraints were removed and a balanced flow of work was scheduled. While these improvements are very significant, they could be said to be a function of how bad the situation was at the start. It is fair to say that before undertaking this programme, this shipyard was considered as being average for a UK shipyard. The facilities were conventional in that covered shops provided manufactured items while ship construction took place on three uncovered inclined berths. A wet dock accommodated snips after launch. An unusual feature was a module shop alongside a unit outfitting hall. These were used for the construction of equipment modules and for the pre-erection outfitting of engine room units.

6. General Principles of Design for Production

The objective of applying Design for Production techniques is the reduction of production costs to a practical minimum, whilst meeting conceptual design requirements and maintaining acceptable quality. This leads to consideration both of reducing inherent work content and of adopting correct materials.

The technical organisation should reflect the concept of Design for Production and enable the procedures to be effected.

The traditional role of the ship designer is the preparation of an overall design of vessel which will have a performance in service which satisfies the Statement of Requirements.

The concept of Design for Production, however, requires that, in satisfying the Statement of Requirements, the ship designer should also give attention to ease of production. This suggests, therefore, two aspects of the overall design, namely:

a. Design for Performance

b. Design for Production

Clearly there will be areas of interaction and the role of the ship designer could be seen in this context as one of arbiter, having the ultimate responsibility of deciding whether performance or production considerations should take precedence in any particular case, or the nature of the compromise to be reached.

Many of the procedures proposed involve consideration of every feature of the ship from an overall viewpoint. Any tendency to divide design into the traditional elements of steelwork, outfit, machinery and piping would provide a totally inadequate basis upon which to build an effective organisation of Design for Production. Consideration of the inter-relationship between one element and another is essential and the term integrated design is used, to define this concept.

7. Organisation for Change

Much of this presentation is about changes in design, in production technology and production sequence. It is easy to state the changes required and to justify that changes should happen. It is less easy to actually bring change about.

Many organisations resist change, sometimes quite unconsciously, perhaps because of tradition or habit, perhaps because of insecurity. Healthy organisations welcome and actively encourage change when it is related to a sensible longer term strategy. In particular, the organisation should see itself evolving to embrace the relevant developments in ship and production technology, and this careful evolution should be seen as a function of the organisation.

Many of the developments proposed in this presentation do, in fact, have a quite dramatic impact on the day to day work of technical, procurement and planning departments. The change in production sequence brought about by pre-erection and advanced outfitting, whilst making production management easier, in fact complicates the provision of technical information.

The traditional approach to production sequence parallels the sequence of design development and engineering. It is often very difficult to change the logic of design development and so the plea is often made for further design lead time. Whilst this is invariably desirable, it is not always possible.

8. The Question of Lead Time

Shipyards in Europe, Scandinavia and Japan have traditionally subdivided the delivery time of ships by creating an extensive period prior to starting production for detailed design, planning and production engineering. This has allowed the greater development of Design for Production techniques and procedures. A short ship production cycle time, characteristic of those countries, itself requires a longer lead time to carry out the necessary technical work to allow cycle times to be reduced. The overall delivery period has not, until relatively recently, been significantly shorter as a result. The extensive investment in Design for Production procedures has, however, now facilitated shorter lead times whilst still improving productivity.

The process of improving productivity can be considered under the following headings:

- Designing work content out of the ship design.
- Improving the efficiency of production processes.
- Making better use of working hours.
- Reducing ship production cycle times.

Design for Production is primarily concerned with the first and last categories but procedures have Denefits, direct or indirect, in the other categories. If productivity is to be increased the question is not one of whether to implement Design for Production but rather how to implement and to what extent. The traditionally shorter lead times in some US shipyards will therefore present a problem until benefits in terms of shorter production cycle times accrue.

9. Implememting Design for Production Procedures

Many Design for Production procedures, particularly relating geometry and block breakdown, do not of themselves affect lead time significantly and a start may be made on their implementation even in cases of very short lead time. Other procedures, particularly equipment and ship module techniques, do require an investment both in time and manpower to realise the potential benefits. In these cases it will be necessary for each individual shipyard to review its own position and define the extent of implementation.

In both cases, however, the implementation will in fact consist of two parallel and inter-related processes:

- Generalised experience and practice gained by systematically attempting to implement procedures by the Ship Designer on designs which are produced at the enquiry stage and may or may not be built, together with the feedback or experience from specific ships. Experience can also be gained by looking at the published designs of overseas competition in the light of their production facilities. Visits by Ship Designers to overseas yards should incorporate a study of the extent to which the suggestions made in this report and more advanced procedures have been adopted.
- Specific experience from ships actually built by the yard. This is gained by taking the technical work of the procedures right through to the production stage and comparing achievement with the objectives set. Again the most relevant procedures may be selected.

By consciously deciding to implement Design for Production in this way and by involving all the appropriate members of the technical and management team, experience gained on specific contracts can be added to the general body of experience so that-design decisions may be taken in a routine manner to combine the requirements of design for performance and production.

Considerations of lead time fall into two overlapping areas:

- Techniques which allow more extensive application of Design for Production procedures in the time available - however short. These are concerned with digesting the general experience in applying procedures into design decision methods. This process can be regarded as an extension of the approach to standardisation in the yard. In particular, it will be vital to incorporate decision rules to define the most suitable block breakdown for the yard facilities, especially as far as the relationship to maximum plate length is concerned.
- Techniques which themselves reduce the necessity for lead time, These are mainly concerned with the application of computer methods to the design development and production information processes. Applications cover not only naval architectural considerations but also steelwork, accommodation layout, pipework and electrical design.

Lead time requirement is a product of the level of technology employed and the balance chosen within total contract execution between lead time and production time. In making the transition to longer lead times the vagaries of the orderbook will be a dominant factor in order to achieve continuity of production. This will imply a phasing of the implementation of Design for Production procedures defined to suit each individual yard.

10. The Need for Design Teams

The technical organisation concerned with Design for Production must reflect a number of functions:

The role of the Ship Designer as arbiter between operational and production considerations.

The concept of integrated design as defined in 6.2.3.

The preparation of production information in a format convenient for interpretation by production manpower.

One way to achieve this would be through the formation of design teams, whose composition should be multi-disciplined. The. leader of each team should act in a liaison capacity with senior planning and production personnel during the development of any one design.

The primary duties of a design team are as follows:

- To produce a design which represents an acceptable compromise between the demands of performance and production.
- To ensure that all design features are compatible with known characteristics of the shipyard facilities.
- To apply Design for Production in so far as it is relevant to the particular shipyard where the vessel is to be built.
- To co-ordinate the inter-relationship between the engineering and outfitting work with the structural work, in order to create a fully integrated design.
- To develop appropriate design standards whose characteristics are fully in line with the Design for Production concept.

11. Conclusions

a. It is essential to consider the problem of cost reduction as a total exercise if substantial savings are to be made. This will involve all departments in a shipyard acting in a concerted manner. A piece-meal approach will only achieve piece-meal savings.

b. Significant reductions in cost are possible and are achieved in two main categories:

i. **A total approach to the ship project, i.e.:**

a clear definition of the contract

designing work out of the ship

reducing the cycle time of production

improving the productivity of the labour force

ii. **A total approach to cost control, i.e.:**

adopting budgetary control procedures

materials and production control procedures which match the sophistication of the facilities

engineering standards on which to base forecasts of cost to completion and justification of design or method changes

c. The single most significant contribution to cost reduction is series production because of the opportunities it creates for advanced production methods.

d. The maximum influence over total cost is available before the contract is signed and in the initial stages following contract signature. Little influence is possible once production has started.

e. The methods to be employed at this stage come under the general heading of design for production and may lead to a saving in total direct manhours of at least 25%.

f. The effectiveness of overheads may be improved by increasing throughput. This is cumulative in the sense that the analysis necessary to achieve cost reducing methods such as pre-election outfitting require a larger overhead, but lead to savings many times their cost.

g. Design for production techniques allow the ship designer to approach the problem of production cost reduction in a systematic manner.

h. It is vital to approach the design of the vessel in an integrated way. The traditional split between steel structure design, machinery and outfitting design increases the cost of the ship.

i. It is necessary to shift the emphasis in defining the configuration of a bulk carrier towards its relationship with hull module length which, in turn, implies a strong influence by the maximum material lengths which the shipyard can handle.

j. A breakdown of the hull into natural blocks is essential to reducing berth cycle time. The bonding of blocks in the machinery space should relate to the functional separation of machinery systems to enable pre-erection outfitting to be maximised.

k. Many factors affect the productivity of the labour force, but labour productivity in the US is generally only half that in Scandinavia and Japan. This is not related to motivation out to the total ship production systems (yard facilities and organisation) existing in these countries. The difference is explained in roughly equal parts between:

ship producibility

facilities and production techniques

organisation, systems and the workforce

l. Ship production technology is advancing rapidly and shipbuilding companies must organise themselves to take maximum advantages of the changes.

m. Many of the changes in production technology have a major impact on the work of the design and engineering departments. These departments will require assistance in the form of computer aids and investment in standards if they are to contribute.

n. A reorganisation of design departments into multi-disciplinary design teams should be considered.

o. The format of production information will require development to match the organisation of production into work stations.

INTEGRATING THE ENGINEERING AND PRODUCTION PROCESS *
VIA

- INTERACTIVE COMPUTING
- GRAPHICS
- PARTS DATA BASE

GRUMMAN AEROSPACE CORPORATION

PAUL WIEDENHAEFER - THE SHIP BUILDING ENGINEERING/PRODUCTION INTEGRATION WORKSHOP
HARLEY HOTEL, - ATLANTA, GEORGIA
JANUARY 20,1981

*Reproductions of the slides used by Mr. Wiedenhaefer in this presentation have been omitted from this report. Anyone desiring a copy of these slides contact M. I. Tanner, Newport News Shipbuilding.

"INTERACTIVE GRAPHICS LOOKS AT PRODUCT MANUFACTURING AT GRUMMAN AEROSPACE"

"*INTERACTIVE* GRAPHICS LOOKS AT PRODUCT *MANUFACTURING* AT GRUMMAN AEROSPACE"

INTRODUCTION :

Having accomplished the capability to geometrically describe within the computer an aircraft design using interactive computer graphics, certain follow-on uses of that data become apparent.

After describing in Part I - "How GEMS (Grumman Engineering and Manufacturing System) Came Into Being", we will discuss in Part II - "Interactive Computer Graphics and Direct Numerical Control in the Machining Operations Department" and Part III - "Application of Interactive Computer Graphics In The Manufacturing Technology Department", our plans and progress-to date toward feed-down of geometrical data to numerical control operations for tooling and fabrication. Our strategy is to evolve GEMS toward ultimately providing every cost-justified use of this engineering data by Grumman's Product Manufacturing Operations.

In closing, Part IV will address some of our "Key Considerations and Areas of Concern".

PART I - HOW GEMS (GRUMMAN ENGINEERING/ MANUFACTURING SYSTEM) CAME INTO BEING

PART I

HOW GEMS (GRUMMAN ENGINEERING AND MANUFACTURING SYSTEM) CAME INTO BEING

BY

Paul Wiedenhaefer - Director of GEMS Program

The first step, in establishing the GEMS (Grumman Engineering and Manufacturing System) program was the formation of a corporate AD HOC Committee in 1974 to review and study interactive computer graphics and to recommend a course of action that would best help achieve the goal which was to provid. Grumman with the capability of achieving lower cost products by means of an interactive graphics CAD/CAM program.

After about eight (8) months of study the AD HOC Committee summarized their findings and made the following recommendations:

- o Appoint someone to be responsible for all aspects of interactive *computer* graphics in Design, Drafting and manufacturing.
- o Procure (lease) four (4) IBM 2250 Mod 3 scopes.
- o Procure (lease) the Lockheed CADAM software package.
- o Initiate training by Lockheed included as one of the available options when leasing or buying the CADAM. software package.
- o Identify a small dedicated team to continue in-depth evaluation.

As a direct result of the AD HOC Committee recommendations a “Computer Aided Design, Drafting and manufacturing program" was initiated by Corporate Direction in 1975 having the organization as shown in Figure I-1.

This corporate program organization was assigned the overall task which was to obtain, develop, and apply computer-aided interactive graphics as a tool to aasist in the design, drafting, date-release and manufacturing phases of the production *of* Grumman Products.

This overall task consisted of the following three parts:

Task I - Obtain. and evaluate an existing system thru actual usage in a "Pilot" program (i. e., Lockheed's CADAM and IBM's 2250 Mod 3 scopes).

Task II - Review and evaluate industry trends in software and hardware.

Task III - Define, recommend and upon corporate approval implement a follow-on program.

The small dedicated team that was formed as recommended proceeded to do each on the above tasks.

Task I

We have completed Task I and the results of our "Pilot" program demonstrated that CADAM versus conventional methods saves manhours for the tasks as given in Figure I-2. The data obtained from our "Pilot" program shows two basic conclusions.

o Lockheed's CADAM software and IBM's 2250 Mod 3 scopes are very cost effective and,

o It is most advantageous to buy the software and hardware.

Task II

We reviewed and evaluated industry trends in three major areas. First, we looked at what other Companies, primarily aerospace but not limited to aerospace, were doing or planing to do in the area of CAD/CAM programs. Particular attention was focused on their use Of interactive computer graphics. Second, we studied all available software packages including those that came as part of "turn-key" hardware systems like Computer Vision and Applicon. Third, we reviewed and analyzed all of the hardware currently available or projected to be available.

The resulting recommendation was that Grumman should "move out" instantly by:

- o Buying the Lockheed CADAM source code.
- o Installing more refreshed graphic scopes in key Grumman plants using a “hard wired” tunnel net work.
- o Combining the Lockheed CADAM system and the already existing in-house interactive graphic programs into a <u>total</u> system called GEMS (Grumman Engineering and Manufacturing System).
- o Proceeding to provide interfaces with the other computerized systems in use at Grumman as shown in Figure I-3.

<u>Task III</u>

In order to define, recommend and upon corporate approval implement a follow-on program. The following basic assumptions were made and approved:

- o CAD/CAM will become and stay as “A Way of Life”.
- o Grumman will stay in the same product line.
- o Interactive Computer Graphics becomes a full “GO” program in January 1976 (The year 1975 being the “Pilot” program period).
- o The “Cradle-to-Grave” geometry and data base savings can only be obtained If we start at the cradle stage. (i.e., the early proposal phase).
- o The “build-up” must be accomplished in an orderly and timely manner resulting in equipment and procedures being in place and operating smoothly.

A schedule of this “build-up” was established by deciding when we wanted to have a mature system available for production use. The timing used in our recommended implementation plan for full fledge use on a major program is as follows:

- o 1976, 1977 and 1978 will be the “build up” years to get equipment and procedures in place operating smoothly .
- o 1979 and 1980 will be used to mature and test the total system.

Having established an overall schedule for the “build-up” of the equipment, systems training and procedures, our next step was to “cost out” this implementation plan to see if it would be cost effective or will the return on the investment (ROI) justify proceeding thru to the 1981 time frame established as the year the entire system will have full fledged use on & major program.

The necessary ingredients of an ROI analysis consists of all of the cost items required such as:

- o Fixed Assets and Facilities for system.
- o Labor
- o All other indirect and associated costs, and

& tally of all the savings that are projected from use of the system thru the 1981 time span. These savings being accrued on a yearly basis by comparing the costs of doing the jobs by conventional means versus the use of the interactive computer graphics system.

Now, having the costs and the savings projected thru 1981 then a ROI can be calculated based on a discounted cash flow basis. Any ROI less than 20% would not be considered very good since putting the same money in a savings bank will yield at least that much ROI.

Let’s look a little closer at the steps in the ROI analysis.

A. <u>The Fixed Assets and Facilities Costs</u>

In order to arrive at these costs we had to establish what equipment, how much of it and where. We found that the best way to establish this was to look at the pacing item - (How many scopes?). This immediately lead to the next pacing item which determined how many scopes, that was - (How many drawings?). We projected the number of drawings that would be produced by means of interactive computer graphics for each year, 1975 thru 1981, as shown in Figure I-4, and overlayed the max. capacity of the scopes based on the projected “build-up” of scopes, starting with 2 in 1975 to 52 by 1981. Having established the number of scopes, scope hours and associated items that go with each scope or scope hour usage, we could then determine all of the fixed assets and facilities needed year by year along with all the associated cost items such as; computing facilities required to provide the level of computing capability that would meet the projected requirement which included:

a) Adding one 370/168 dedicated computer system in a separate, isolated, secure (closed) area.

b) Adding one back up power supply for this computer and,

c) Adding switching capability to switch load to other already existing 370/168 computers in emergencies.

B. Labor

The labor or the manpower consisted of three parts. Part 1 was the labor to develop a functioning system. Part 2 was the labor to maintain the overall system in an operational production mode. Part 3 was the labor to make the necessary enhancements that development use of the system dictates necessary for a good production system. These labor or manpower projections were summarized in total corporate man years for each year 1975 thru 1981. The man years were then converted to dollar costs by applying the proper rates.

C. All Other Indirect and Associated Costs

This consisted of the projected need and corresponding costs of the following items year by year thru 1981.

a) Software lease or buy costs.

b) Equipment maintenance.

c) Training Costs

d) Travel, Office Supplies, Repro Services, Publications, etc.

e) Equipment leases or any required item not purchased and included under fixed assets.

f) Computing services to support the interactive computer graphics system.

D. The Savings

The savings used in the ROI analysis of our proposed implementation plan consisted solely of that type documented during our pilot program which was the making of drawings and doing the N/C program work by means of interactive computer graphics versus the existing conventional method. The down stream savings in tooling and manufacturing and the savings in the sustaining period in the area of E.0. (Engineering Order) incorporation and ECP (Engineering Change Proposal) activity were not used. We believed that these savings would be quite significant, but because we were still in the stage of documenting these savings, we conservatively chose not to include them at this time.

E. The Cash Flow

The actual cash flow by year was then obtained by summing up all the costs and all the savings, year by year. Quite as expected, our cash flow was negative in the beginning years. It became positive by the middle of 1979 and rapidly increased as a positive cost flow.

The ROI

The ROI for our basic implementation plan was then calculated using the data generated and the standard discounted cash flow equations. The resulting ROI was over 50% thus showing that our implementation plan had a good cash flow and a good return on the dollars being invested in this new system.

In summary

GEMS came into being because the -

- o Task I "Pilot" program proved that CADAM is very cost-effective.
- o Task II industry survey and trends indicated that our proposed system was the best available system, both near-term and "down-stream", and
- o Task III implementation plan shows a good cash flow and ROI.

With this data we proposed that corporate management should make a positive decision to move ahead with CADAM and interactive computer graphics (GEMS) and they did in January 1976.

PART II

INTERACTIVE COMPUTER GRAPHICS AND DIRECT NUMERICAL CONTROL IN THE MACHINING OPERATIONS DEPARTMENT

By: Rudolph Remake

In the Machining Operations Department our task as noted before, has been to learn how to use the system, then seek out and demonstrate applications, We are now at the point where we are using GEMS for production work while continuing our quest for applications and training additional people in the use of the system. Part of the task is to integrate the system with those which already exist and to define enhance - ments needed.

The Machining Operations Department is charged with the operation and support of machining installations in two locations: Bethpage, N. Y.; and Glenarm, Md. There are some 80 pieces of major milling equipment, mostly heavy duty multispindle profilers. There is approximately 250,000 sq. ft. of floor space devoted to machining between the two plants. In this paper, Interactive Graphics and Direct Numerical Control and their relationship to the technical support function are described.

Row dose Interactive Graphics *and DNC* fit *into* the system today? This can best be described by going through the communicatioa network shown in Figure II-1.

Methods and Tool Design - Data is input on the CADAM scopes. The drawings so generated are sent via Punched tape to a flatbed plotter for hardcopy output. The math model generated by the structural designer and the drafts - man is used as the basis for their task.

Numerical Control Programming - The traditional punched card, punched tape environment is still with us. The implementation of IBM MDAP (Machining and Display Application Program) and the installation Alphanumeric scopes it supports has brought about a welcome change for the N/C programmer. Most of the editing, debugging, and processing is done on these CRT terminals.

Hard copy listings and punch tape, where used, are handled by the RJE terminal. For the tape proveout phase, the IBM 5275, which has local disk storage, is used to drive the machine tool. The units are portable and Plug in BTR. Data is sent over a phone line from the main frame to load the disk. The unit is also used to drive the flatbed plotter eliminating a tremendous amount of punched tape. This system is termed "Pre-production DNC" at Grumman and is intended for debugging and processing APT source programs from the shop floor and driving the machine tool during the tape proveout cycle. For production Work, that is, jobs which are proved out and optimized, tapes are punched in the conventional manner.

The first two parts selected to demonstrate the N/C capability in GEMS were chosen becauae they represent part configurations normally expected in *aerospace* structure (See Fig. II-2, -3). The first is a typical longeron design about five feet long requiring four axis machining; the second is a relatively simple bulkhead configuration approximately 14 X 20 inches with pockets, canted stiffener tops and five axis machining on the externs contour. The entire tooling package consisting of the workholder design, shop documentation and N/C tapes were prepared for this bulkhead utilizing GEMS. (See Fig. II-4, -5, -6).

Other applications demonstrated and now being used *for* production *include N/C* tapes for:

- o Manufacture of tools
- o Routing of sheet metal parts
- o Injection molds
- o Drilling detail machined parts

Projected savings of 40-50% in Tool Design and N/C programming and 25-30% in Methods Engineering are being realized.

What do we expect to do in tine future?

- o Install additional hardware
- o Continue training, upgrade operator competence
- o Define and cost justify enhancements to existing system
- o Expand production use

The future communication network, Fig. II-7, encompasses all the features noted Previously Plus several important additions. First of all, more graphic and alphanumeric scopes have been installed. The largest single addition is the “Production DNC” System which, at this time, is not precisely defined. An electrostatic plotter has been installed and Is being used for production. Although this piece of equipment is intended for check prints, many feel that the quality is good enough for final drawings in some applications.

We have introduced Interactive Graphics and DNC, we are using them for production work and we intend to expand their use.

PART III

APPLICATION
OF
INTERACTIVE COMPUTER GRAPHICS
IN
GRUMMAN AEROSPACE CORP
MANUFACTURING TECHNOLOGY DEPT.

PART III

APPLICATION OF INTERACTIVE GRAPHICS IN THE MANUFACTURING TECHNOLOGY DEPARTMENT

By: Robert Sanderson

While machining operations been been using the resources of the computer and of numerical control at Grumman extensively, use of the computer for other cross of manufacturing has been somewhat restricted. With the advent of computer graphics, however, a powerful tool is being added to these other areas so that they too are utilizing the resources of the computer. The remaining part of this presentation will deal with the application of interactive computer graphics in the Manufacturing Technology Department - especially In connection with tooling activities at Grumman.

Originally we shared the four (4) 2250 scopes with the previously mentioned disciplines within the company. This year we have dedicated hardware in our own environment. We are training Manufacturing Technology personnel from Methods Engineering, Tool Design and Mechanical Processes areas. In doing so, we are enhancing all aspects of Manufacturing Engineering with the benefits of computer graphics. Specialists from assembly, welding, forming, handling equipment and bonding tool design groups have been trained and continue to increase their proficiency at the scopes. Our tasks are for the most part project work. However, a fair part is left for applications, and for additional training. Here are some applications:

Tool designs are being generated at the scopes. Hard copy output has been obtained from the flat bed plotters as shown in Figure III-1. Our new Versatec plotter is operational and gives a fast service for check prints. We also use Versatec output for shop copy. The automatic dimensioning and analysis facillties of interactive graphics has virtually eliminated the time consuming descriptive geometry aepects of tool design. Perhaps the largest advantage is when the engineering design iS accessed and tool design commences directly upon it. An example is shown in Fig III-2. Figures III-3 and III-4 show two of eight detail drawings of a large apply fixture for our EF-111 airplane. All of the details were copied to generate the assembly drawing, Fig. III-5. This job not only dispelled an early fear that large tools could not conveniently be generated at the scope, but showed that there is in actuality a larger gain in terms of tool drafting time. Fig. III-6 shows the flat pattern template which was generated for a truncated sheet metal exhaust pipe. Scope time was approximately one hour for a job that was estimated at 2 days when laid out manually. Figs. III-7 and III-8 show our attempts with generating chem-milling operation sheets at the scope. Other applications are mylar drawings for lay-up of composites bonding strips, and generating cutter and drill paths for templates. In the latter application, we are now deeply involved in producing all press block templates, and all flat pattern sheet metal parts for a revision to our F-14 Navy Fighter.

Our future plans call for the increase of multi-axis N.C. machines for the fabrication of tools and tool components thru interactive graphics for such tools as Press Blocks, Stretch Dies, Bonding Fixtures, and Assembly tools. In so doing, we will eliminate or decrease requirements for control and coordination media such as Plaster Mock-Up Fixtures, Tooling Masters and Gages, Models, and Templates. All coordination between actual production tools will therefore be achieved thru machine tool means rather than thru traditional methods.

The scenario for these plans is simply shown in Fig. III-9 and Plays accordingly: Product definition is generated at the scope. It is accessed by Methods Engineering at which location the appropriate tooling is authorized. It is again accessed in the respective tool design areas to generate tool design drawings and N.C. tapes for these tools, and N.C. tapes for standard detail parts tools such as forming dies. Of course economic analysis will be made as to where emphasis is to be given in selection of tools to be generated using these means.

Figs. III-10 thru III-12 show projected savings on a large new program where all engineering and most tooling is accomplished at the scope. Number of tool design drawings is reduced as the requirement for tooling masters is reduced. In the area of assembly tools, we can see a large reduction in both numbers and manhours required to produce the masters for them. Although the numbers of assembly production tools will essentially remain constant, the manhours required to produce them will be reduced as machine tools replace the hand skills. In the area of detail parts tools, we can see a similar trend. A large reduction in both numbers and manhours required to produce the templates for them will be realized. There will be some reduction in the numbers as well as the manhours required to produce detail parts production tools as drill. and router tools and others are eliminated and as more machine tools are used to produce the remaining ones.

One striking example of the old versus the new approach is seen in Figs. III-13 and III-14. Figure III-13 shows the tooling family heretofore required to produce a bonding fixture. Depending on circumstances, all or most of the mock-ups, masters and models might be required to produce the desired end item - the bonding fixture. In the future, the bonding fixture will be produced directly, as shown in Fig. III-14, on an N.C. machine which will have obtained the surface cutter path generated at the scope. Delivery position of the bonding fixture is enhanced by at least several months.

The advantages of interactive graphics for tooling are as follows:

- o <u>Lower overall tooling costs</u>
  As the requirements for certain tools are eliminated or reduced and the time associated with the remaining tools is reduced, overall tool design and tool fabrication program costs are reduced.
- o <u>Earlier tool delivery</u>
  Where tooling tools such as mock-up fixtures, models, masters, templates, etc. are no longer required in order to coordinate production tools, delivery of those production tools is vastly improved.
- o <u>No cumulative tool errors</u>
  It is possible to accumulete and transmit errors thru each successive tooling tool step - especially in a complicated family tree scheme - to the point where tolerance of the production tool is compromised. There will be no cumulative errors where that production tool is generated directly on a N.C, machine tool.

- o *Faster tool repair/rework*

  Engineering revisions will be incorporated directly into the production tools rather than into the tooling tools first as is the current practice.

- 0 *Reduce storage space*

  The warehouse costs in terms of space, handling, and salaries are reduced with the reduction in requirements of tooling tools.

- o *Decrease dependance on manual and of disappearing. skills*

  The move to produce more production tools on N.C. machine tools will decrease the requirement for such crafts as model makers, and plastermen. The use of the band saw and file will be replaced by more exacting machines.

- o *Decrease production problems*

  When all aircraft components are either machines or formed from machine tools which obtained their instructions from a single data engineering bases they will mate with greater precision. Parts and sub assembly coordinetion will improve to the point where assembly will Progress more efficiently end there will be a reduction in scrapped or reworked parts with an increase in overall qualitY.

We are also aware of Potetial problem. Our concerns with using computer graphics are as follows:

- o *Heavy recuirement and reliance on N.C. machine tools*

  Economic justification must be made for investment of additional capital hardware. This is generally only done on new programs where there Is a large volume of tools required. For instance, an all metal fighter may require up to 10,000 form blocks to produce component aircraft parts. Initial study shows that this is a fertile area for computer graphics application. However, before committing ourselves heavily, we must have demonstrated that the new techniques for tool fabrication are bug-free. We are doing this at present in our applications efforts.

- Errors in math model may not be apparent until tool is completed or in use

  Engineering data must be verified before subsequent use for activities such as tooling. New inprocess checks and procedures must be devised for tool fabrication processes.

- Shift in type of personnel required

  Personnel in the methods and tool design areas while not becoming computer programmers are becoming computer users. product definition is understood to reside in computer memory rather than as metal or mylar lofts or as blueprint dimensions. Emphasis will increasingly change from craft skills to machine skills in tool fabrication shops. Reeducation and revisions to planning and philosophies are required.

PART IV
KEY CONSIDERATIONS & AREAS OF CONCERN

PART IV

KEY CONSIDERATIONS AND AREAS OF CONCERN

There is always two sides to a coin. Parts I thru III have addressed the positive side. Before we close or end this paper, I would like to step back and look at the other side of the coin because we must make sure that we look at the total Picture in true perspective. An until we have done that, I do not believe we have portrayed a total projection, evaluation and impact of interactive computer graphics.

Some of our key considerations and areas of concern are:

- Must go all the way - a partial effort is wasted (cannot go part way and have 1/2 a baby).
- Must provide ample margin in equipment facilities, people (cannot suddenly hire equipment and trained people or go to a vendor).
- Once the math model data base system is established as the base for all Depts. & Systems on a program -- Engineering cannot -- nor can any other department relapse into the "old way" even in small or isolated areas (You have stepped off the cliff).
- You hasten the demise and disappearance of certain skills which already are scarce.
- You must pay the costs of two systms (old and New) during a lengthly period.
- You become very capital intense and locked into equipment, systems and a smal1 crew of highly trained, uniquely skilled people.

These considerations and concerns forces . . . .

- Perceptive and precise long-rang planning, and
- Extreme corporate, departmental, sectional and program discipline

if the long haul program is to be successful.

DESIGN/PRODUCTION INTEGRATION IN IHI
(SUMMARY)

IHI MARINE TECHNOLOGY, INC.

Y. ICHINOSE

January 20, 1981

1-1 OBJECTIVES OF DESIGN/PRODUCTION INTEGRATION

- Reduce Engineering and Production Costs
- Shorten Periods between Contract Award and Delivery (Overlap of Design-Procurement-Production)
- Improve Working Environment and Safety
- Improve Product Quality
- Adhere Production Schedules

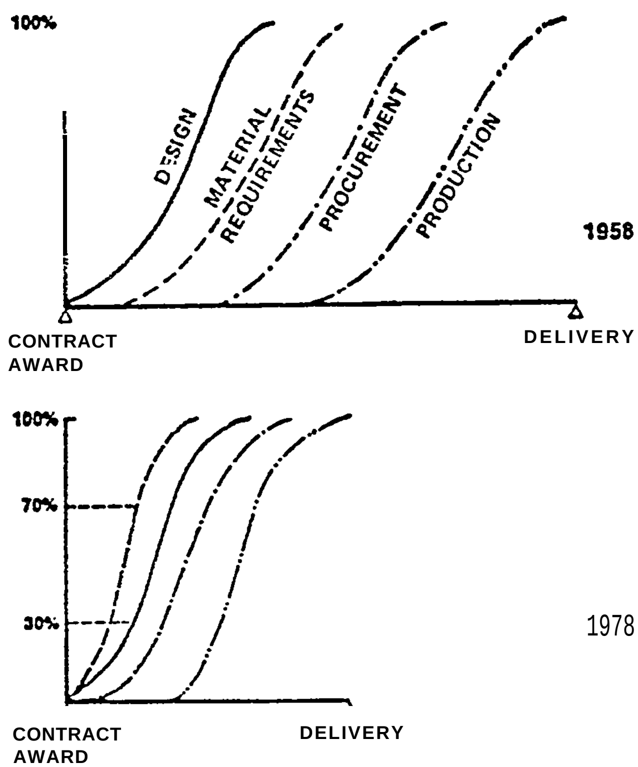


FIGURE 1-1: Overlap of outfit design, material definition, procurement and production which has been achieved by the most competitive shipbuilders. When only 30% of a design is completed, 70% of its required material is defined.

1-2 RESPONSIBILITIES OF DESIGN AND PRODUCTION FUNCTIONS

Design

1. Responsible for ship's functional performances to meet client's specification requirements.
2. Translate specification requirements into detail plans and instruction for production.

Production

1. Responsible for overall quality and workmanship of end product.
2. Produce end product based on design requirements at mininum cost and time.

1-3 ROLE OF DESIGN AND PRODUCTION TO IMPROVE PRODUCTIVITY

Dcsign

1. Engineer plans and instructions incorporating production needs and requirements to improve productivity (product-oriented design).
2. Provide accurate and punctual informations to purchasing and production to meet production schedule.
3. Minimize design changes to avoid setbacks in production.

Production

1. Devise optimum production flow, work breakdown structure, production techniques and appropriate facilities to maximize productivity.
2. Provide necessary informations and feedbacks to design to accomplish above objectives,

2 INTEGRATION OF DESIGN AND PRODUCTION FUNCTIONS IN IHI

2-1. Work Breakdown Structure

Work Packages	Production Method
Hull Construction	Hull Block Construction Method (HBCM)
Outfitting	Zone outfitting Method (ZOFM)
Painting	Zone Painting Method (ZPTM)
Pipes	Pipe Piece Family Manufacturing Method (PPFM)

2-2 MANAGEMENT CYCLE

FUNCTION	BASE STRUCTURE
ESTIMATING	SYSTEM-Oriented
DESIGN - Basic Design (Key Plans)	SYSTEM-Oriented
- Detail Design (Working Plans)	Transformation from SYSTEM to ZONE
PRODUCTION - Scheduling	ZONE-Oriented
- Execution	ZONE-Oriented
- Evaluation	ZONE-Oriented Transformation from ZONE to SYSTEM for feed back to estimating and design

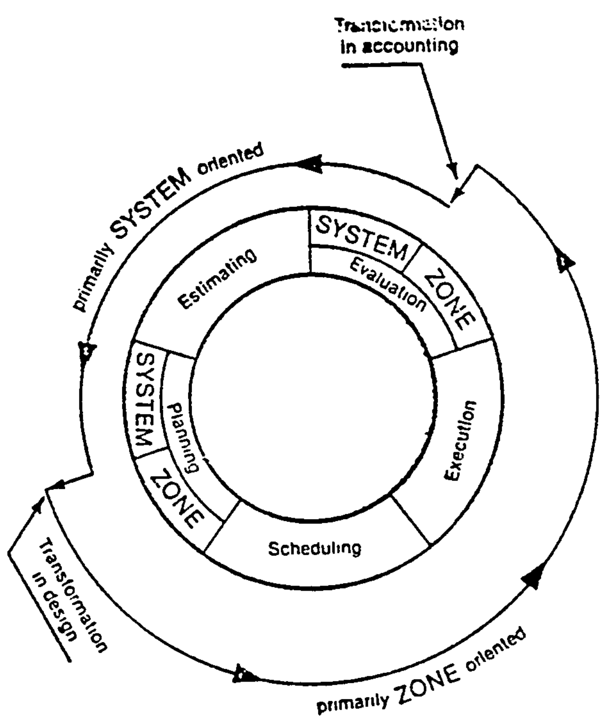
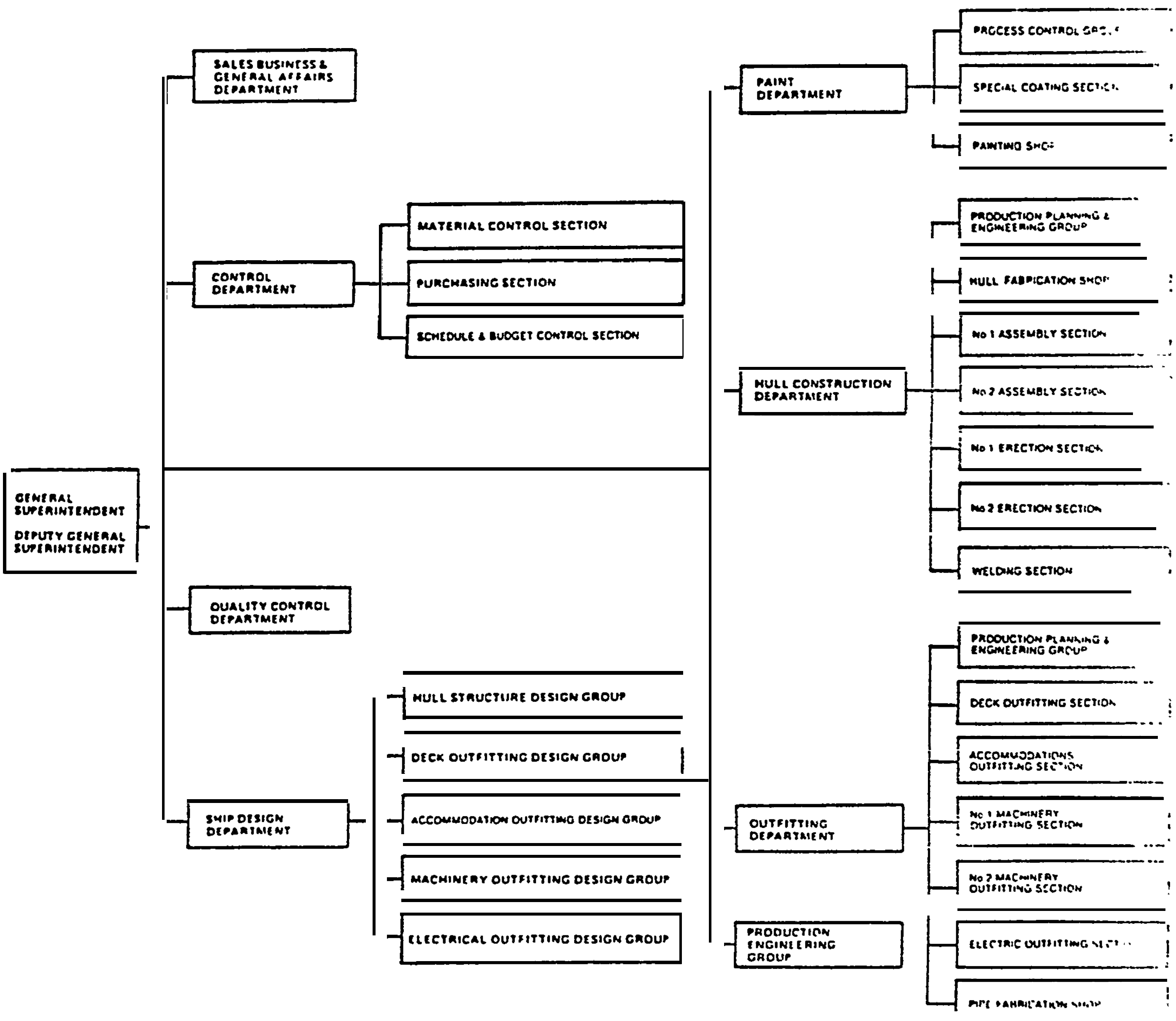


FIGURE 2-1: Dual grouping in the management cycle facilitated by a Product Work Breakdown Structure (PWBS). Design and material definition are aspects of planning. Material procurement is as much a part of executing as is producing.

2-3 SHIPYARD'S ORGANIZATION



2-3 SHIPYARD'S ORGANIZATION

RELATIONSHIP BETWEEN DESIGN FUNCTIONS TO PRODUCTION FUNCTIONS

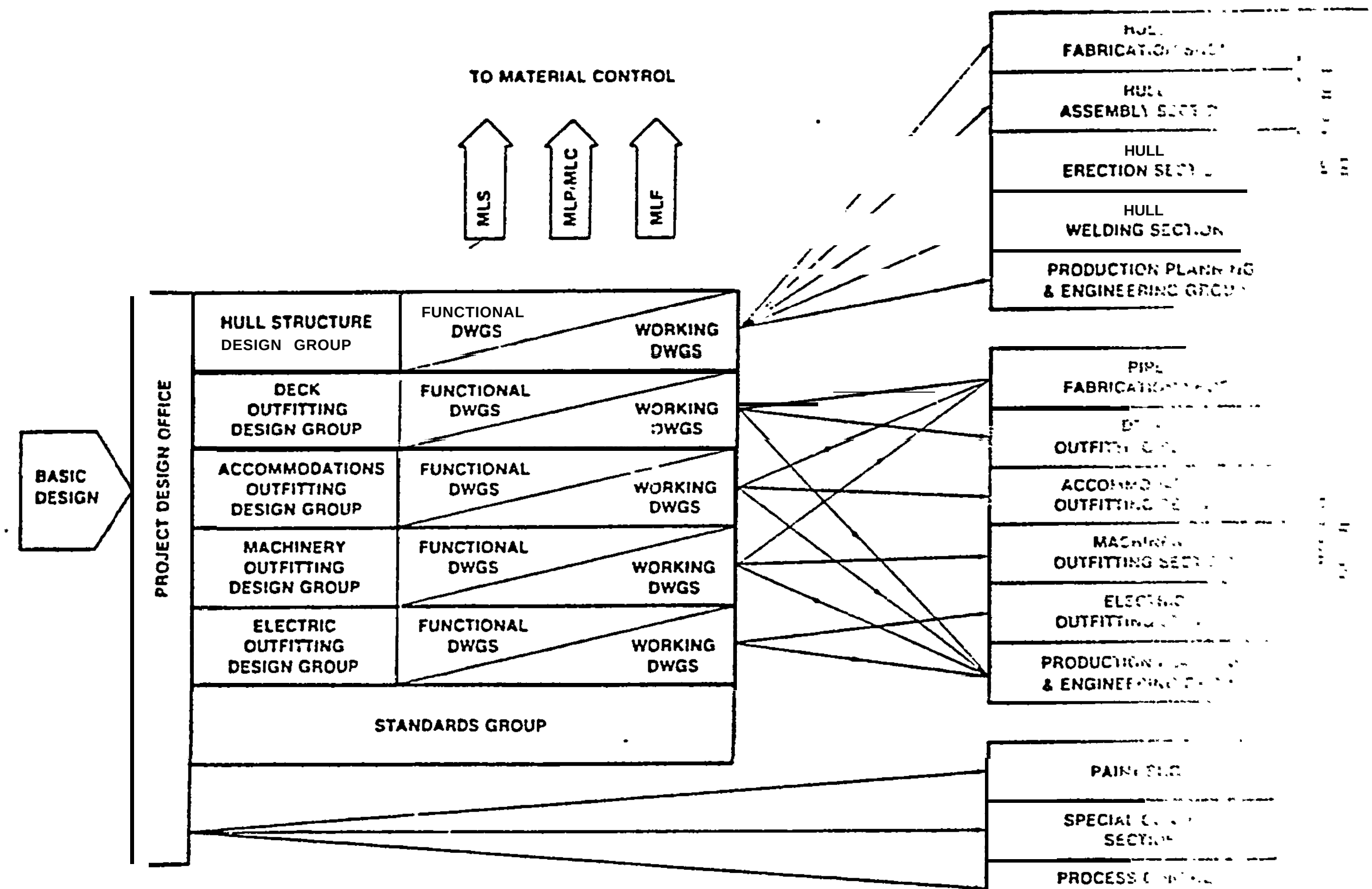
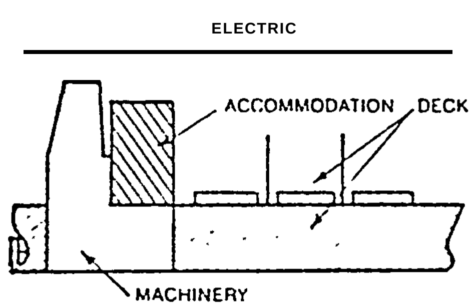


FIGURE 3-2: **Relationships of design functions to production functions.**



MATERIAL

SCHEDULE

COST

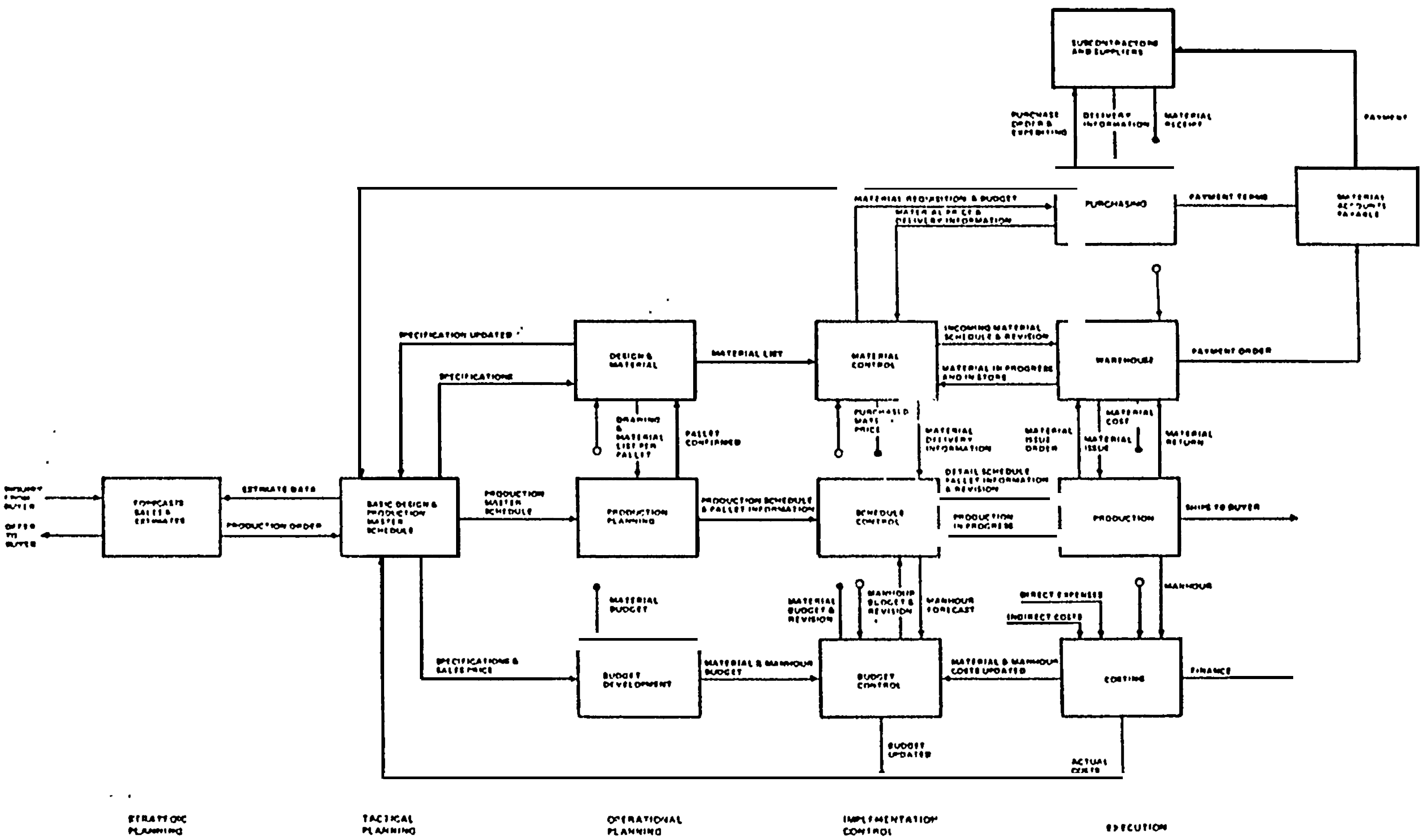
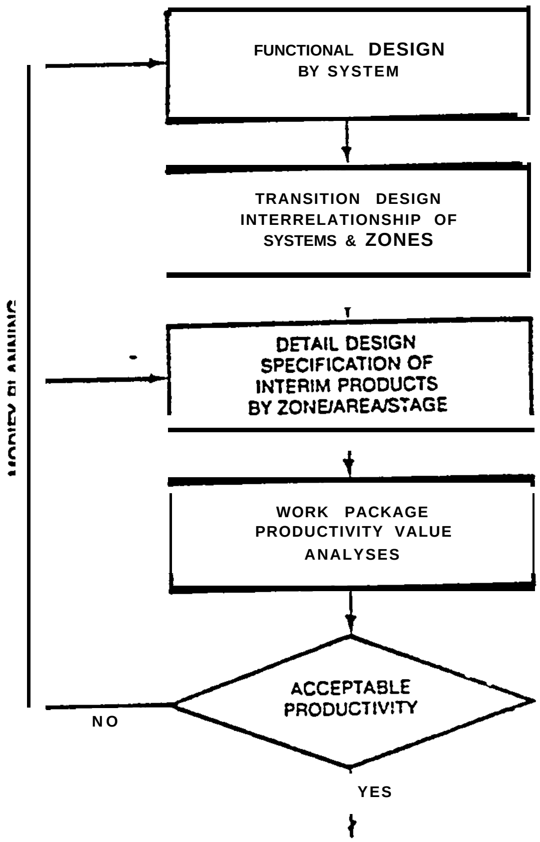


FIGURE 6-1: Information flow among shipbuilding functions.

3-1 DESIGN FLOW

TRANSFORMATION OF DESIGN TO WORK PACKAGES



3-1 DESIGN FLOW

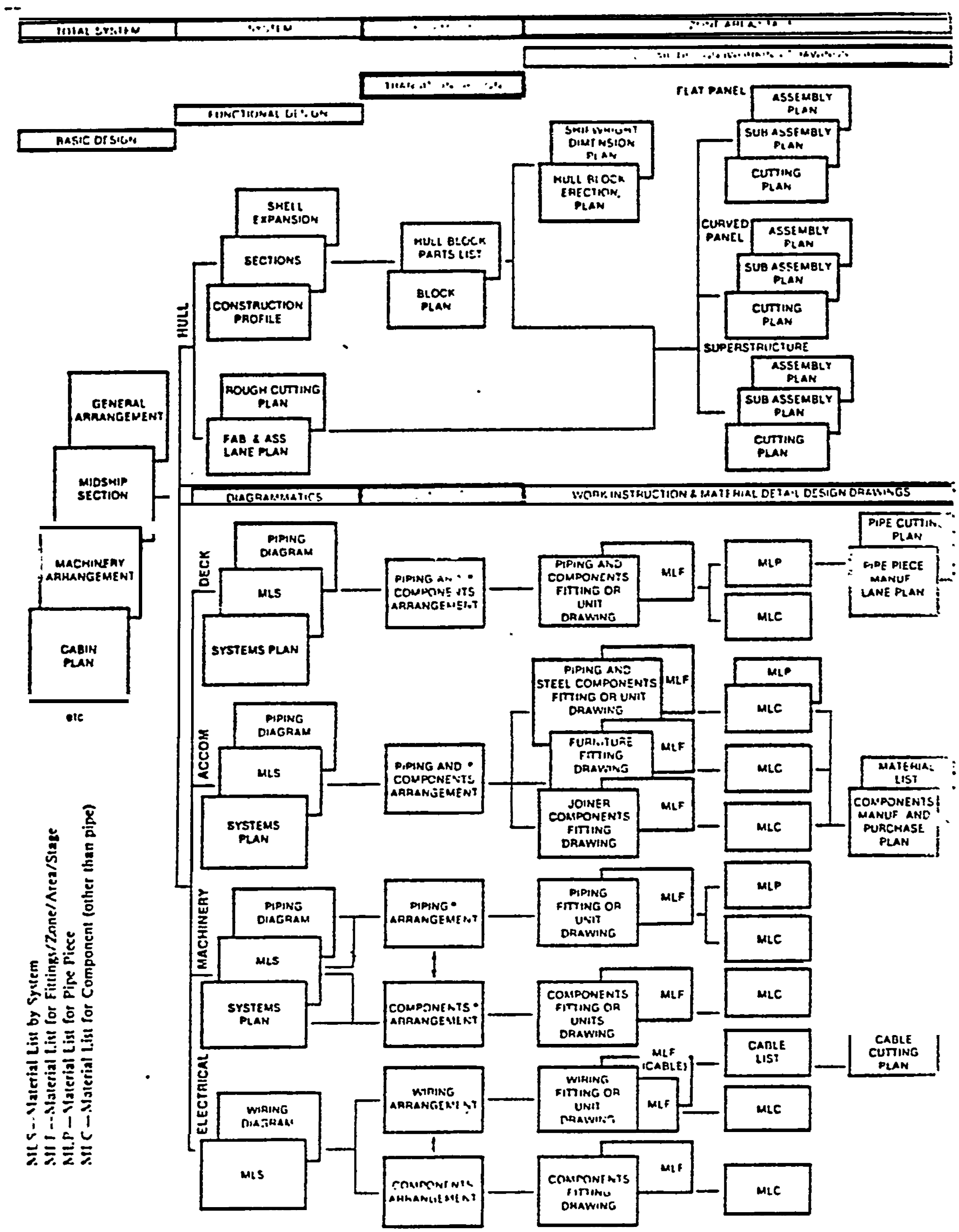
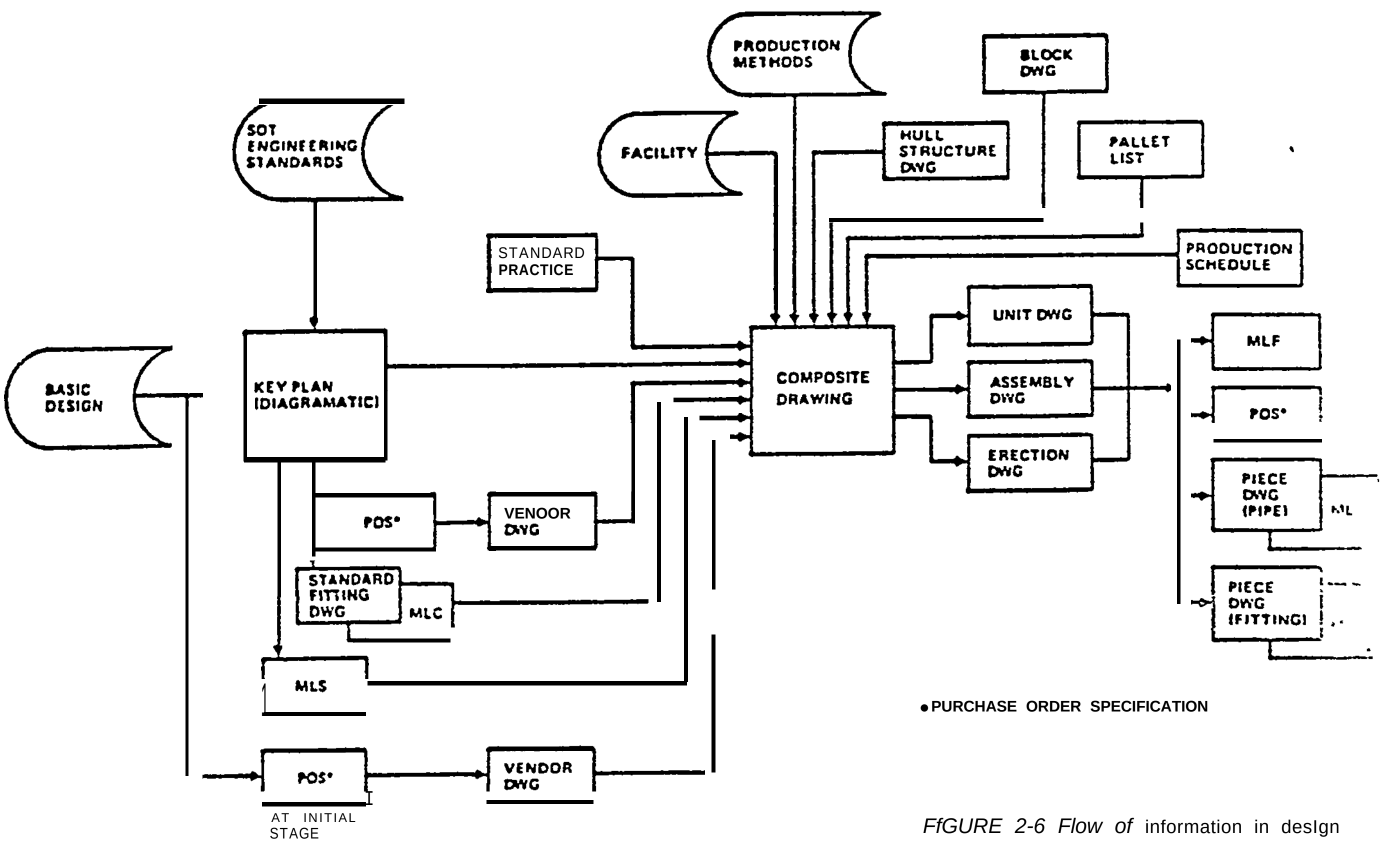


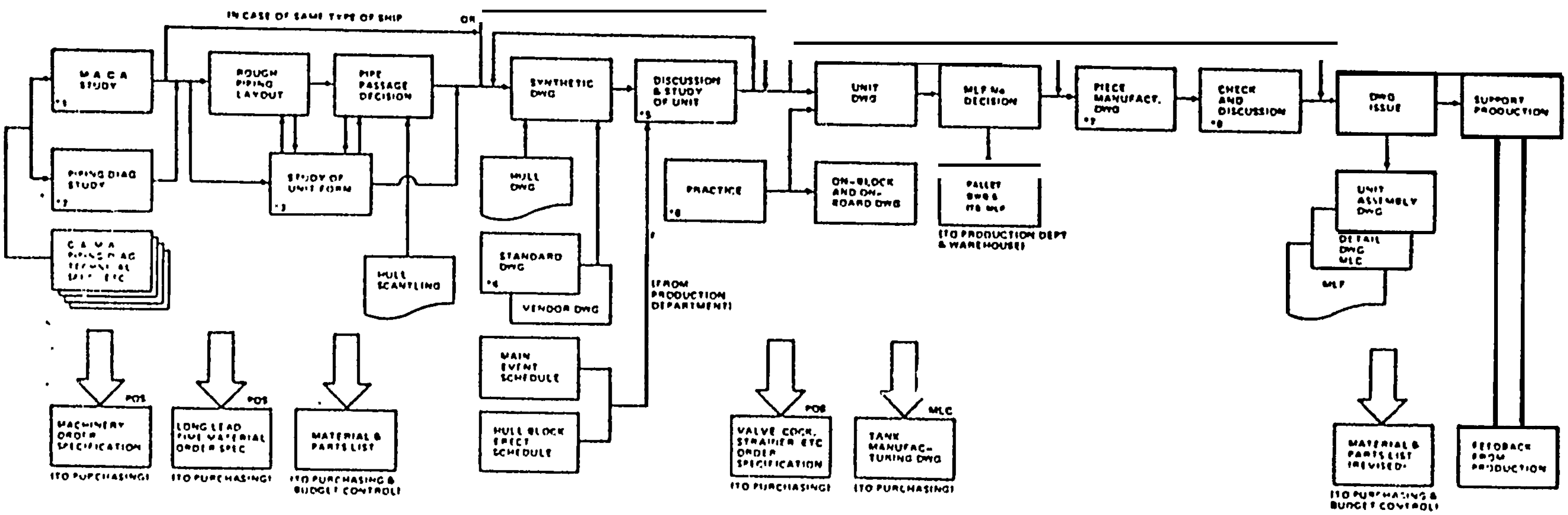
FIGURE 2-2 Product-oriented Design Process. Transition Design introduces zones and interrelations with systems. The items marked "*" are sometimes freehand. But, they are sufficient for quickly conveying arrangements and system/zone relationships to detail designers. The latter refine arrangements and designate stages during preparation of work instruction and material detail-design drawings.

3-4 FLOW OF INFORMATION IN DESIGN



FfGURE 2-6 Flow of information in deslgn

COMMUNICATION FLOW IN ENGINEERING (OUTFITTING)



*NOTES

*1 - ... GENERAL ARRANGEMENT	*2 - PIPING DIAGRAMMATICS	*3 - UNIT FORM	*4 - DESIGN STANDARDS
1 ... 2 ARRANGEMENT OF MACHINERY 3 REVIEW OF OPERABILITY AND MAINTAINABILITY	1 REVIEW OF ABILITY 2 REVIEW OF CAPACITY 3 REVIEW OF COMPONENTS CONSIDERING OPERABILITY & REDUCTION IN SIZE OF PLANT	1 WHERE CAN THE ZONE & PARTS BE PACKAGED? 2 WHERE IS THE ZONE FITTING JUST FOR THE UNIT?	1 STANDARD UNIT DWG 2 STANDARD PIECE DWG 3 CHECK LISTS 4 ETC
*5 - REVIEW OF UNIT	*6 - STANDARD PRACTICE	*7 - FABRICATION DWGs	*8 - FINAL REVIEW
1 ASSEMBLY PROCEDURE 2 LOADING PROCEDURE 3 ON-UNIT → ON-BOARD? OR ON-UNIT → ON-BLOCK? 4 RELATION TO HULL BLOCK ERECTION SCHEDULE 5 RELATION TO HULL BLOCK ERECTION METHOD 6 WHERE CAN ZONE & COMPONENTS BE FITTED JUST FOR ON-BLOCK OUTFITTING?	1 PIPING PRACTICE 2 FLOORING PRACTICE 3 INSULATION PRACTICE 4 VENTILATION PRACTICE 5 ETC	1 PIPE FAB DWG 2 VENT DUCT DWG 3 FLOOR & GRATING DWG 4 LADDER DWG 5 MACHINERY SEAT DWG 6 SPINDLE DWG 7 PENETRATION PIECE DWG 8 MAIN ENG EXH GAS PIPE DWG 9 UP-TAKE DWG 10 PIPE SUPPORT DWG 11 COAMING, GUTTER DWG	1 UNIT DIVISION 2 UNIT ASSEMBLY PROCEDURE 3 UNIT LOADING PROCEDURE 4 PRACTICES 5 ETC

3-5 PURCHASING

Flow of Information and Material

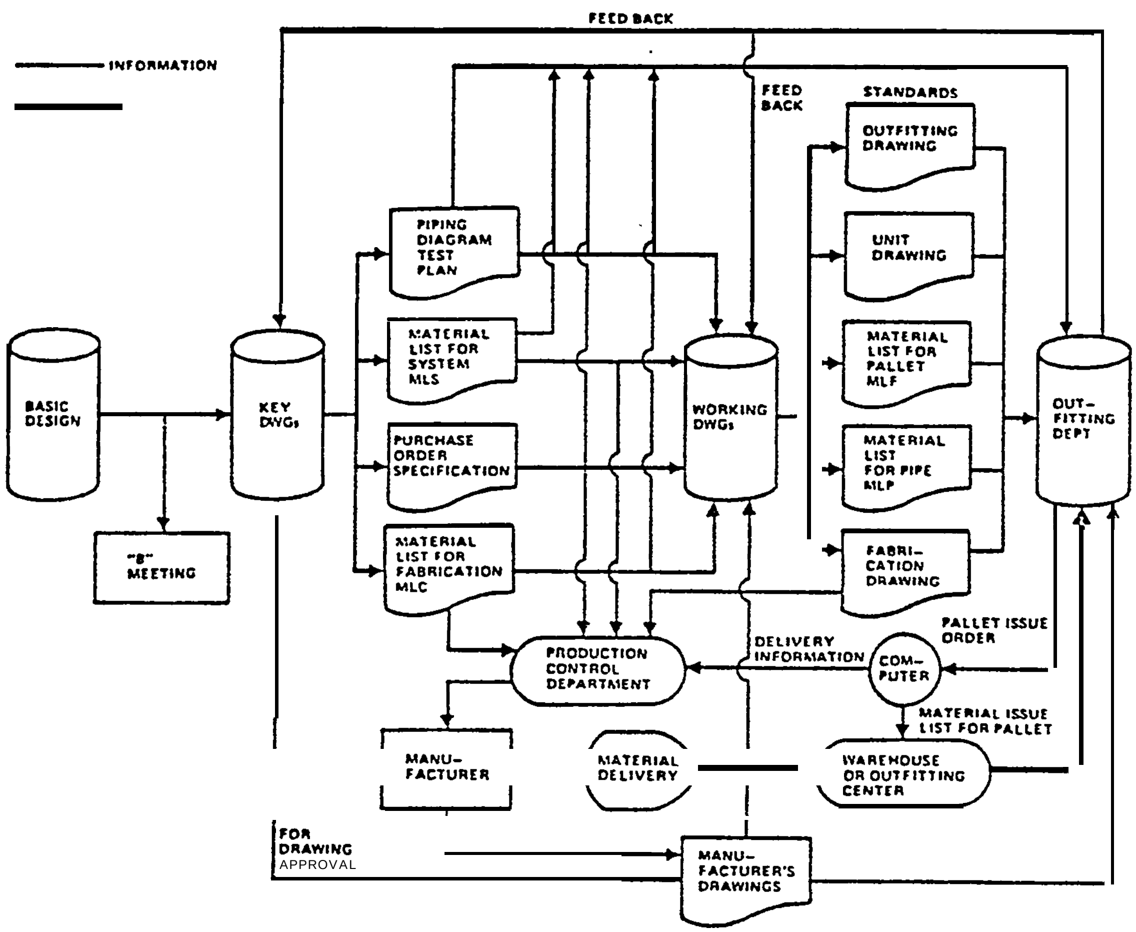
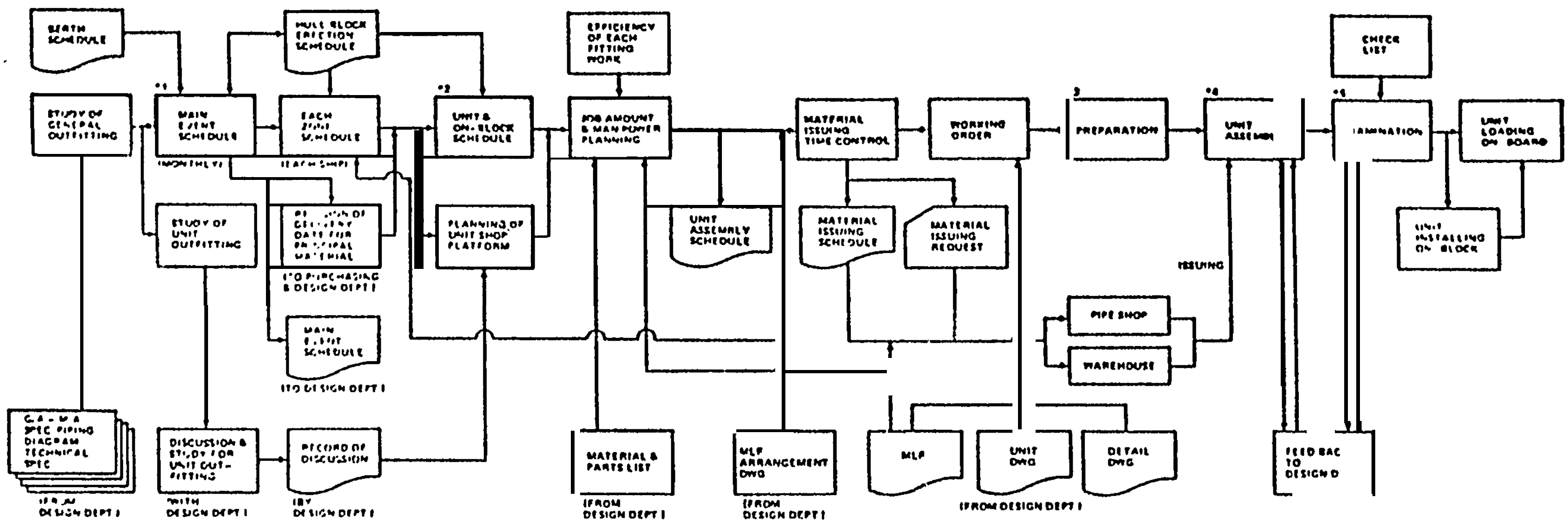


FIGURE 2-19: Flow of information and material.

COMMUNICATION FLOW IN PRODUCTION PLANNING/SCHEDULING (OUTFITTING)



*NOTES –

*1 – EXAMPLES OF EVENTS	*2 – SCHEDULES.	*3 – PREPARATION	*4 – PROCEDURE·	*5 – REVIEW (Q.A.)
1 START CONSTRUCTION 2 KEEL LAYING 3 CARGO OIL PUMP UNIT ERECTION 4 DIESEL GENERATOR ERECTION 5 BOILER ERECTION 6 SHAFT SIGHTING 7 MAIN SWITCH BOARD ERECTION 8 HATCH COVER ERECTION START 9 MAIN ENGINE ERECTION 10 PROPELLER FITTING 11 LAUNCHING 12 BOILER FIRE-UP 13 DIESEL GEN. RUNNING TEST 14 MAIN ENG. STARTING TEST 15 ETC ABOUT 30 – 36 EVENTS FOR ONE SHIP	1 MONTHLY SCHEDULE 2 WEEKLY SCHEDULE 3 LEVELING FOR OTHER SHIP UNIT ASSEMBLY (CAPACITY PLANNING)	1 REVIEW OF UNIT ASSEMBLY PROCEDURE 2 PREPARATION OF MACHINE & TOOLS 3 CHECK OF ISSUED MATERIAL (NUMBER, FORM ETC)	1 MARKING 2 SETTING OF MACH. SEAT 3 SETTING OF PIPE SUPPORT 4 INSTALLATION OF MACHINERY 5 FITTING OF VALVE, COCK, PIPE STRAINER, SPINDLE, HOPPER ETC. 6 FITTING OF FLOOR SUPPORT & FLOOR 7 HANDRAIL & STANCHION 8 FITTING CABLE WAY & ELECTRIC EQUIPMENT 9 EXAMINATION (SEE *5) 10 PAINTING 11 TRACER PIPE FITTING 12 INSULATION 13 PROTECTION	DIMENSION CHECK CHECK OF COMPLETE WELDING CHECK OF COMPLETE BOLTING CHECK OF COMPLETE PROTECTION CHECK OF COMPLETE PAINTING REINFORCEMENT FOR LIFT UP CHECK SAFETY FOR TRANSPORTATION ETC

FIGURE 5-10: Unit outfitting procedure in production.

5-1 Formal Meetings (Per Ship Contract)

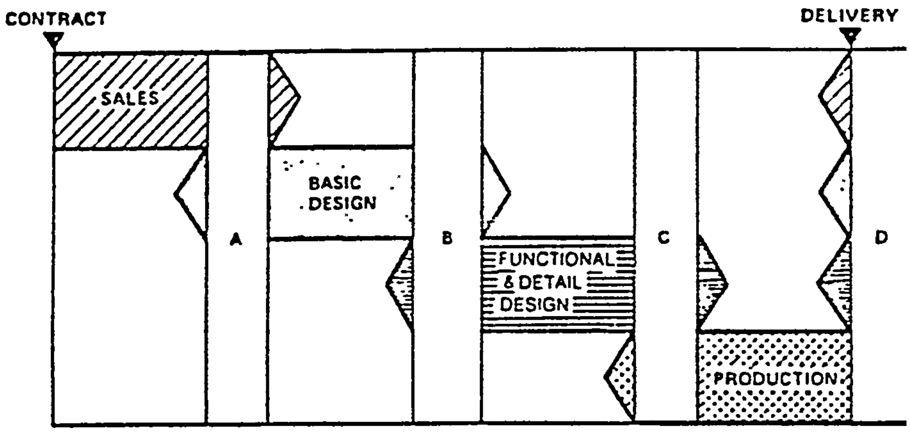


FIGURE 2-17: A–B–C–D meetings. Formal meetings are treated as essential milestones to ensure continuous communications and coordinated planning.

Meeting	Time	Participants	Agenda
A-Meeting	Contract Award	- Sales - Accounting - Basic Design - Production Control	- Contract background - Specifications & Contract Terms - Cost & budget - Key events schedule - Information of Owners
B-Meeting	Transfer of design from Basic Design to Shipyard Design	- Basic Design - Yard Design - Sales Shipyard Management Production Control Purchasing - Production	- Same as A-Meeting - Transfer of Contract plans and Key plans (basic)
C-Meeting	Transfer from design to production	- Yard Design - Production - Production Control - Purchasing	- Special design & material requirements - Palletization grouping, coding, methods, etc. - Detail schedule
D-Meeting	Immediately after ship's delivery	- Design - Sales - Production Control - Production	- Technical, material schedule & budget Evaluations - Guarantee items